

R  
249193

JPRS-UPM-84-003

9 July 1984

# USSR Report

PHYSICS AND MATHEMATICS

DTIC QUALITY INSPECTED 2

19980318 114

DISTRIBUTION STATEMENT A

Approved for public release;  
Distribution Unlimited

**FBIS**

FOREIGN BROADCAST INFORMATION SERVICE

REPRODUCED BY  
NATIONAL TECHNICAL  
INFORMATION SERVICE  
U.S. DEPARTMENT OF COMMERCE  
SPRINGFIELD, VA. 22161

5  
156  
A08

#### NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

#### PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service (NTIS), Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semimonthly by the NTIS, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

Soviet books and journal articles displaying a copyright notice are reproduced and sold by NTIS with permission of the copyright agency of the Soviet Union. Permission for further reproduction must be obtained from copyright owner.

JPRS-UPM-84-003

9 JULY 1984

USSR REPORT

PHYSICS AND MATHEMATICS

FOREIGN BROADCAST INFORMATION SERVICE

REPRODUCED BY  
NATIONAL TECHNICAL  
INFORMATION SERVICE  
U.S. DEPARTMENT OF COMMERCE  
SPRINGFIELD, VA. 22161

#### NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in parentheses supplied by JPRS. Processing indicators such as (TEXT) or (EXCERPT) in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originated with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

#### PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service (NTIS), Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semimonthly by the NTIS, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

Soviet books and journal articles displaying a copyright notice are reproduced and sold by NTIS with permission of the copyright agency of the Soviet Union. Permission for further reproduction must be obtained from copyright owner.



9 July 1984

# USSR REPORT

## PHYSICS AND MATHEMATICS

### CONTENTS

#### ACOUSTICS

Excitation of Shock Vibrations At Resonance in Two Ultrasonic Magnetostrictive Transducers Facing One Another (V.V. Klubovich, I.K. Vagapov, et al.; DOKLADY AKADEMII NAUK BSSR, No 1, Jan 84).....	1
Thermooptical Excitation of Surface Acoustic Waves in Solid (V.V. Krylov, V.I. Pavlov; AKUSTICHESKIY ZHURNAL, No 6, Nov-Dec 82).....	1
Waveguide Isolation of Flexural Waves (S.I. Kovinskaya, A.S. Nikiforov; AKUSTICHESKIY ZHURNAL, No 6, Nov-Dec 82).....	2
Noise Field of Sources Concentrated Near Faces of Wedge (A.M. Karnovskiy; AKUSTICHESKIY ZHURNAL, No 6, Nov-Dec 82).....	2
Phase-Conjugate Reflection In Sound Beams Via Four-Phonon Mixing With Thermal Waves (F.V. Bunkin, D.V. Vlasov, et al.; AKUSTICHESKIY ZHURNAL, No 6, Nov-Dec 82).....	3
Efficiency of Wavelength-Thickness Vibration Damper Coating (V.M. Bochkarev, V.B. Stepanov, et al.; AKUSTICHESKIY ZHURNAL, No 6, Nov-Dec 82).....	3
Relation Between Lateral Displacement of Ultrasonic Beam and Attenuation Coefficient For Normal Waves (Yu.B. Sviridov; AKUSTICHESKIY ZHURNAL, No 5, Sep-Oct 83).....	4
Directivity of Radiation From Flabellate Interdigital Converter Of Surface Acoustic Waves (S.I. Koba; AKUSTICHESKIY ZHURNAL, No 5, Sep-Oct 83)....	5

Polarization of Ultrasound During Passage Through Boundary Between Magnetically Inactive Medium and Equatorially Magnetized Medium (G.A. Babushkin; AKUSTICHESKIY ZHURNAL, No 5, Sep-Oct 83).....	5
Transitory Radiation of Sound By Mass Source Moving Above Uneven Surface (V.I. Pavlov, A.I. Sukhorukov; AKUSTICHESKIY ZHURNAL, No 5, Sep-Oct 83).....	6
Changing Direction of Propagation of Surface Acoustic Waves By Means of Periodic Unevenness (Yu.Yu. Alyakna, V.P. Plesskiy; AKUSTICHESKIY ZHURNAL, No 5, Sep-Oct 83).....	6
Determination of Pressure Gain In Acoustic Antenna Array From Measurements in Fresnel Zone (V.L. Zemlyakov, S.G. Nikeshin; AKUSTICHESKIY ZHURNAL, No 5, Sep-Oct 83).....	7
Synthesis of Antennas for Location Near Reflecting Surfaces (V.B. Galanenko, L.G. Krasnyy, et al.; AKUSTICHESKIY ZHURNAL, No 5, Sep-Oct 83).....	7
Dependence of Acoustic Properties of Sound Absorbing Fibrous Materials On Their Structure (N.N. Voronina; AKUSTICHESKIY ZHURNAL, No 5, Sep-Oct 83).....	8
Cross Spectrum of Radiated Noise Signal and Signal Reflected By Multilayer Sea Bed (V.V. Krasnoborod'ko; AKUSTICHESKIY ZHURNAL, No 1, Jan-Feb 84).....	8
Parametric Excitation of Transverse Acoustic Slot Waves In Solids By Means of Microwave Electric Field (T.I. Bondarenko, G.N. Burlak; AKUSTICHESKIY ZHURNAL, No 1, Jan-Feb 84).....	9
Study of Sea Bed Unevenness With Amplitude-Modulated Signal (I.V. Sheynfel'd; AKUSTICHESKIY ZHURNAL, No 1, Jan-Feb 84).....	9
Resonance Scattering of Sound Waves By Elastic Spherical Shell Immersed in Fluid (A.P. Poddubnyak; AKUSTICHESKIY ZHURNAL, No 1, Jan-Feb 84).....	10
Dispersion Curves For Normal Waves in Cylindrical Shell Under Condition of Space Coincidence Within Vicinity Of Critical Frequencies (V.V. Muzychenko, A.P. Paniklenko, et al.; AKUSTICHESKIY ZHURNAL, No 1, Jan-Feb 84).....	10

Calculating Horizontal Refraction of Sound Waves By Shallow Sea By Perturbation Method (Yu.A. Kravtsov, V.M. Kuz'kin, et al.; AKUSTICHESKIY ZHURNAL, No 1, Jan-Feb 84).....	11
Radiation From Equatorial Spherical Zone With Pulsating Surfaces (S.B. Keleberdenko, I.L. Oboznenko, et al.; AKUSTICHESKIY ZHURNAL, No 1, Jan-Feb 84).....	11
Simulation of Vibratory Processes in Damped Structures With Temperature-Frequency Characteristics of Vibration Absorbing Materials Taken Into Account (L.Ye. Buvaylo, A.V. Ionov; AKUSTICHESKIY ZHURNAL, No 1, Jan-Feb 84).....	12
Natural Vibrations of Membrane In Infinitely Long Waveguide (B.P. Belinskiy; AKUSTICHESKIY ZHURNAL, No 1, Jan-Feb 84).....	13
Relation Between Pressure Pulse Generated In Optoacoustic Receiver and Intensity of Stimulating Laser Pulse (Yu.N. Ponomarev, S.B. Ponomareva, et al.; IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: FIZIKA, No 11, Nov 83).....	13
Excitation of Pressure Pulse in Water With Explosive Vaporization of Surface Layer (A.F. Vitshas, V.V. Grigor'yev, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 23, Dec 83).....	14
Sound Field of Turbulent Wake (L.M. Lamshev, A.T. Skvortsov; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 24, Dec 83).....	15
Investigation of Opto-Acoustic Phase Characteristics of Fiber- Optics Light Guides With Different Structures (I.L. Bershteyn, A.N., Gur'yanov, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 12, Dec 83).....	15

#### CRYSTALS AND SEMICONDUCTORS

Anomalies of Spin-Lattice Relaxation in Crystals with Defects Near Points Of Structural Phase Transitions (A.P. Levanyuk, B.V. Moshchinskiy, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 1, Jan 84).....	17
--	----

Nonlinear Scattering Of Radio Waves By Metal Objects (V.B. Shteynshleyger; USPEKHI FIZICHESKIKH NAUK, No 1, Jan 84).....	17
Angle Dependence On Frequencies Of Polar Optical Phonons. In TlSe and Its Structural Analogs (R.A. Aliyev, K.R. Allakhverdiyev, et al.; DOKLADY AKADEMII NAUK AZERBAYDZHANSKOY SSR, No 9, Sep 83).....	18
Effect of Electric Field on Mechanical Strength of GaSe Single Crystals (S.A. Abasov, M.Kh. Elmira Jalal Kizi, Aliyeva, et al.; DOKLADY AKADEMII NAUK AZERBAYDZHANSKOY, No 9, Sep 83).....	19
Acoustooptics Of X-Rays (M.V. Balakhanov, V.I. Pustovoyt, et al.; IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK, No 5, Sep-Oct 83).....	20
Energy Levels of Selenium Impurity in Germanium (Yu.A. Osip'yan, V.M. Prokopenko, et al.; PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, No 3, Feb 84).....	21
Amplification of Traveling Magnetostatic Waves By Parametric Pumping (A.V. Bashkovskiy, V.I. Zubkov, et al.; PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, No 3, Feb 84).....	21
The Crystalline Structure of $\text{Na}_5\text{Nd}_4[\text{SiO}_4]_4(\text{OH})$ (Yu.A. Malinovskiy; DOKLADY AKADEMII NAUK SSSR, No 1, 1984).....	22
Nonlinear Optical Electoreflexion in Germanium And Silicon (O.A. Aktsipetrov, Ye.D. Mishina; DOKLADY AKADEMII NAUK SSSR, No 1, 1984).....	23
Calculating Electric Fields in Semiconductor Structures When Singularities Are Present (V.L. Kul'chitskiy, V.P. Plakhotnyy, et al.; DOKLADY AKADEMII NAUK UKRAINSKOY SSR: SERIYA A FIZIKO- MATEMATICHESKIYE I TEKHNIЧЕСКИYE NAUKI, No 12, Dec 83).....	23
Phonon Scattering In A Solid Solution of $\text{In}_{1-x}\text{Ga}_x\text{Sb}$ (M.I. Aliyev, S.A. Zeynalov, et al.; DOKLADY AKADEMII NAUK AZERBAYDZHANSKOY SSR, No 8, Aug 83).....	24



Surface Electromagnetic Wave Dispersion on Semiconductors Having A Periodic Relief Formed with Exposure To Intense Laser Radiation (V.V. Bazhenov, A.M. Bonch-Bruyevich, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 20, Oct 83).....	25
High Efficiency pAlGaAs-pGaAs-nGaAs Photovoltaic Solar Cells With Efficiencies of 19% (AM 0) and 24% (AM 1.5) (V.M. Andreyev, V.R. Larionov, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 20, Oct 83).....	25
Anisotropic Capture of Two Natural Deep Centers During Liquid Phase Epitaxy of Gallium Arsenide (S.I. Chikichev, V.A. Kalukhov; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 20, Oct 83).....	26
Luminescence From Color Centers In Yag-Crystals (Ye.F. Martynovich, A.G. Tokarev, et al.; IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: FIZIKA, No 1, Jan 84)....	27
Effect of Ga and As Sublayers on Interphase Interactions and Thermal Stability of Pd-GaAs Structures (I.D. Romanova, N.K. Maksimova, et al.; POVERKHNOST': FIZIKA, KHIMIYA, MEKHANIKA, No 1, Jan 84).....	27
Use of Asymmetric Reflections In Study of Implanted GaAs Layers By Method of Two-Crystal X-Ray Diffractometry (M.V. Prilepskiy, I.M. Sukhodreva; POVERKHNOST': FIZIKA, KHIMIYA, MEKHANIKA, No 1, Jan 84).....	28
Electrical Characteristics of Metal-Dielectric-Semiconductor Systems Produced on Epitaxial Silicon Structures with Various Dielectrics (O.F. Fomicheva, La.A. Otavina, et al.; POVERKHNOST': FIZIKA, KHIMIYA, MEKHANIKA, No 1, Jan 84).....	29
Thermo-EMF of Semiconductor Heterojunction (N.S. Lidorenko, I.I. Balmush, et al.; DOKLADY AKADEMII NAUK SSSR, No 4, Oct 83).....	29
Luminescence and Level Structure of Impurity Centers In $Y_3Al_5O_{12}:Fe^{3+}$ Single Crystals (M.L. Meyl'man, M.V. Korzhik, et al.; DOKLADY AKADEMII NAUK SSSR, No 3, Jan 84).....	30
Dynamics of Changes in Optical Properties of Semiconductors Under Laser Radiation (A.N. Loparev, L.Ya. Min'ko, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 84).....	31

Solitons in Deformable Ferromagnetic With Anisotropy of the 'Easy Plane' Type (F.Kh. Abdullayev, A.A. Abdumalokov; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, No 11, Nov 83)...	32
Particulars of Photoconductivity of GaSe<Sn> Single Crystals in Vicinity of Fundamental Absorption Edge (V.N. Katerinchuk, Z.D. Kovalyuk; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, No 11, Nov 83).....	32
Optical Charge Exchange of Dopand In GaAs<Cr> (O.V. Vakulenko, A.S. Skirda, et al.; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, No 11, Nov 83).....	33
Determining Position of $\pi$ - $\nu$ Junction in Iron-Doped Gallium Arsenide Epitaxial Structures (N.A. Chernov, M.D. Vilisova, et al.; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, No 11, Nov 83).....	33
Properties of Ge-Doped n-GaAs When Growing Single Crystals From Melt (M.A. Krivov, Ye.V. Malisova, et al.; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, No 11, Nov 83).....	34
Influence That Conditions of Growing Epitaxial GaAs Layers Produced By the Mos-Hybrid Method Have On Photoluminescence Spectra (T.S. Babushkina, T.A. Zeveke, et al.; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, No 11, Nov 83).....	34
Thermostimulated Currents in ZnSe-GaAs Heterostructures (G.T. Vilisov, O.P. Gorbacheva, et al.; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, No 11, Nov 83).....	35
Circular Polarization of Hot Photoluminescence, and Spin Relaxation of Hot Electrons in Gallium Arsenide Crystals (M.A. Alekseyev, I.Ya. Karlik, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 12, Dec 83).....	36
Optical Detection of EPR From Photostimulated Crystal Luminescence (N.G. Romanov, V.A. Petrov, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 12, Dec 83).....	36

Photoinduced Extraction of Radiation From $\text{Ti:LiNbO}_3$ Waveguides With Rotation of Polarization Plane (Ye.M. Zolotov, A.G. Kazanskiy, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 23, Dec 83).....	37
Optical Low-Dose Effect in Solid-State Radiation Physics (R.R. Atabekyan, V.L. Vinetskiy, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 23, Dec 83).....	38
Passage Of Magnetostatic Surface Waves Through Periodic System of Parallel Metal Strips (A.V. Vashkovskiy, A.V. Zubkov, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 23, Dec 83).....	38
Role of Surface In Conductivity and Photoconductivity of Magnetic Semiconductor $\text{CdCr}_2\text{Se}_4$ (V.T. Moshnyaga, K.M. Golant, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 24, Dec 83).....	39
High-Efficiency Photodetector for Ultrasonic Radiation  (Zh.I. Alferov, A.T. Gorelenok, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 24, Dec 83).....	39
Effect of Light Field on Anisotropy of Refractive Index of CdS Crystal (N.A. Vidmont, A.A. Tartakovskiy, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 24 Dec 83).....	40
Classes of Crystals with Square-Law and Cubic nonlinearity that Permit Quasisynchronous Optical Wave Interaction (D.B. Yusupov; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84)...	40

#### ELECTRICITY AND MAGNETISM

Using Relativistic Electron Beams to Generate Microwave Pulses of Microsecond Duration (V.A. Burtsev, N.I. Zaytsef, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 23, Dec 83).....	42
Spatial Coherence of Emission Source with Radiation Patter $\cos^m \theta$ In Longitudinally inhomogeneous Media with Square-Law Refractive Index Profile (S.G. Krivoshelev, N.I. Petrov, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 24, Dec 83).....	42
Investigation of Bragg Reflection of Electromagnetic Surface Waves by Diffraction Grating (K.O. Boltar', G.N. Zhizhin, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 24, Dec 83).....	43

Generation of Intense Microwave Emission by High-Current Microsecond Beam in Triode System (A.N. Didenko, A.G. Zherlitsyn, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 24, Dec 83).....	43
---	----

## FLUID DYNAMICS

Stability of Stationary Rotation of Cylinder Filled With Stratified Viscous Incompressible Fluid (N.V. Derendyayev; DOKLADY AKADEMII NAUK SSSR, No 5, Oct 83).....	45
Formation of Coherent Structures By Acoustical Effects in A Turbulent Wake (N.N. Yanenko, S.P. Bardakhanov, et al.; DOKLADY AKADEMII NAUK SSSR, No 1, 1984).....	45
Transition from Laminar To Turbulent Flow Under Action of Acoustic Vibrations (A.N. Shel'pyakov, A.M. Kasimov, et al.; INZHENERNO- FIZICHESKIY ZHURNAL, No 4, Oct 83).....	46
Propagation of Gas Jet in Liquid (V.A. Surin, V.N. Yevchenko, et al.; INZHENERNO- FIZICHESKIY ZHURNAL, No 4, Oct 83).....	47
Free Oscillations of Ideal Stratified Fluid in Container (N.D. Kopachevskiy, Simferopol, et al.; ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI, No 1, Jan 84).....	47
Completely Conservative Correction of Fluxes in Problems of Gas Dynamics (V.M. Goloviznin, M.A. Ryazanov, et al.; DOKLADY AKADEMII NAUK SSSR, No 3, Jan 84).....	48
Similarity Criteria For Spectra of Pressure Fluctuations in Turbulent Boundary Layer at Wall (B.M. Yefimtsov; AKUSTICHESKIY ZHURNAL, No 1, Jan-Feb 84).....	49
Front Structure of Weak Shock Wave In Relaxing Medium (A.I. Bozhkov, A.I.A. Kolomenskiy; AKUSTICHESKIY ZHURNAL, No 6, Nov-Dec 82).....	49
Evaluating Effect Of Flow On Pressure Field of Monochromatic Point Source In Homogeneous Ocean (O.S. Golod, N.S. Grigor'yeva; AKUSTICHESKIY ZHURNAL, No 6, Nov-Dec 82)	
Noncontradictory Method of Calculating Radiation Transfer, and Problem of Shock Wave Structure (A.I. Vyskrebentsev, V.A. Nuzhnyy, et al.; ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNIЧЕСКОY FIZIKI, No 6, Nov-Dec 83).....	51



Gasdynamic Study of Model With Combustion in Shock Tunnel (V.K. Bayev, V.V. Shumskiy, et al.; ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI, No 6, Nov-Dec 83).....	51
Hypersonic Three-Dimensional Flow of Radiating Gas Around Wing (A.I. Golubinskiy, V.N. Golubkin; ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI, No 6, Nov-Dec 83).....	52
Measurement of Conditionally Averaged Turbulence Characteristics in Plane Wake Behind Cylinder (A.A. Praskovskiy; ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI, No 6, Nov-Dec 83).....	52
Hypersonic Flow of Viscous Gas On Surface Of Blunt Cone With Strong Blow-In In Blunted Region (Yu.N. Yermak; ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI, No 6, Nov-Dec 83).....	53
Unsteady Motion of Circular Cylinder In Two-Layer Fluid (V.I. Bukreyev, A.V. Gusev, et al.; ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI, No 6, Nov-Dec 83).....	54
Longitudinally Oriented Cellular Structures of Taylor-Gertler Vortex Type on High-Pressure Side of Rotating Channels (A.V. Kuz'minskiy, Ye.M. Smirnov, et al.; ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI, No 6, Nov-Dec 83).....	54
Separative Layer in High-Temperature Flows (A.A. Bobnev; ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI, No 6, Nov-Dec 83).....	55
Unsteady Swirling Flow in Cylindrical Channel (A.V. Fafurin, Yu.A. Pustovoty; INZHENERNO-FIZICHESKIY ZHURNAL, No 1, Jan 84).....	55
Theoretical Study of Flow Around Single and Double Steps In Two-Dimensional Channel (A.I. Mayorova; INZHENERNO-FIZICHESKIY ZHURNAL, No 1, Jan 84).....	56
Stability Boundary of Thermally Driven Oscillations In Pipeline Of Variable Cross Section (V.A. Sysoyev, S.P. Gorbachev; INZHENERNO-FIZICHESKIY ZHURNAL, No 1, Jan 84).....	56
Mutual Diffusion Coefficients Of Some Binary Gas Mixtures (L.A. Pozhar, V.N. Shchelkunov; INZHENERNO-FIZICHESKIY ZHURNAL, No 1, Jan 84).....	57

Coefficient Of Surface Friction With Turbulent Flow in Boundary Layer (V.M. Kapinos; INZHENERNO-FIZICHESKIY ZHURNAL, No 1, Jan 84).....	58
Region Of Existence, True Volumetric Phase Concentrations And Hydraulic Drags For Annular Flow Structure of Gas-Liquid Mixtures in Pipes (N.N. Yelin; INZHENERNO-FIZICHESKIY ZHURNAL, No 1, Jan 84).....	58
Process of Liquid Boiling In Rotating Vessels and Channels (S.I. Sergeyev, O.M. Popov, et al.; INZHENERNO-FIZICHESKIY ZHURNAL, No 1, Jan 84).....	59

#### LASERS AND MASERS

Characteristics Of Structural Formation Of Nitride Synthesized By Laser Action Upon Metals (N.N. Rykalin, A.A. Uglov, et al.; DOKLADY AKADEMII NAUK SSSR, No 5, Oct 83).....	60
Improving Energy Performance And Duty Time of Production Process On CW Electrical Ionization CO <sub>2</sub> Lasers by Using Five-Component Lasing Mixtures (A.P. Averin, N.G. Basov, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 20, Oct 83).....	60
Thermoelastic Stability Of Cooled Laser Mirrors (V.V. Kharitonov, S.B. Koshelev; INZHENERNO-FIZICHESKIY ZHURNAL, No 4, Oct 83).....	61
Passive Shutters Using No. 1000 Dye For Picosecond Laser Equipment (V.P. Mikhaylov, M.I. Demchuk, et al.; DOKLADY AKADEMII NAUK BSSR, No 9, Sep 83).....	61
Passive Q-Switching Of Laser Resonator Using Alkali-Halide Crystals With Z-Centers (L.M. Sobolev, E.E. Penzina, et al.; OPTIKA I SPEKTROSKOPIYA, No 6, Dec 83).....	62
Dependence Of Shape Of Laser-Excited Elastic Pulses On Radiation Wavelength (V.I. Arkhipov, A.N. Bondarenko, et al.; AKUSTICHESKIY ZHURNAL, No 1, Jan-Feb 84).....	63
Iris Pulsing Ruby Light Source (Yu.F. Morgun, M.A. Muravitskiy, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 4, Oct 83).....	63

Gain of Waveguide CO <sub>2</sub> -Laser (S.T. Kornilov, S.N. Chirikov; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 4, Oct 83).....	64
Dye-Laser Frequency Converter With Telescopic Resonator (O.D. Gavrilov, K.V. Gratsianov, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 84).....	64
Lasing Of Complexes With Hydrogen Bond of 7-Diethylamino- 4-Methylcoumarin (S.A. Krashakov, A.I. Akimov, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 83).....	65
Validity Limits For Method Of Statistical Moments In Transient- State Theory of Lasers (A.V. Kazberuk, F.V. Karpushko; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 84).....	66
Dye Laser With Distributed Feedback and With Pumping By Copper- Vapor Laser (S.Yu. Mirza, A.N. Soldatov, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 4, Oct 83).....	66
Theoretical Study of Output Spectral Characteristics Of Molecular Laser With Optical Resonance Pumping (M.M. Ivanenko, V.V. Churakov; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 4, Oct 83).....	67
CW YAG-Nd Laser With Passive Stabilization of Self-Mode Locking (A.A. Gusev, S.V. Kruzhalov, et al.; OPTIKA I SPEKTROSKOPIYA, No 5, Nov 83).....	68
Admittance of Heterolasers With Strip Contact In Case Of Reverse Biasing (Ye.D. Karikh; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, No 11, Nov 83).....	68
Scaled Design of Pulsed Gas-Discharge Lasers (V.F. Kravchenko; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, No 11, Nov 83).....	69
Problems Of Emission Formation In Two-Pass CO <sub>2</sub> Amplifier With Phase-Conjugate Mirror (A.A. Betin, V.Ye. Sherstobitov; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 12, Dec 83).....	69
New Type Of Dye Laser With Light-Induced Distributed Feedback (A.D. Das'ko, A.A. Murav'yev, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 12, Dec 83).....	70

Quasi-Waveguide Thin-Film Tunable Dye Laser (V.M. Arutyunyan, G.P. Dzhotyan, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 12, Dec 83).....	70
Improving Efficiency Of Intracavity Laser Pumping Of Selectively Absorbing Media (R.G. Aubakirov, A.G. Murzin, et al.; OPTIKA I SPEKTROSKOPIYA, No 3, Sep 83).....	71
Feasibility of Improving Lamp Pumping Efficiency Of Erbium Glass Lasers (S.G. Lunter, A.G. Murzin, et al.; OPTIKA I SPEKTROSKOPIYA, No 3, Sep 83).....	71
Influence of Magnetic Field On Characteristics Of Competitive Resonance In Ring Gas Laser With Absorbing Cell (M.A. Kos'mina, E.Ye. Fradkin; OPTIKA I SPEKTROSKOPIYA, No 3, Sep 83).....	72
Technical Fluctuations of Gas Laser With Nonlinear Absorption (V.V. Tuchin; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84)....	72
Generation Of Harmonics In Systems Of Free-Electron Laser Type (V.R. Khalilov; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84)..	73
NUCLEAR PHYSICS	
Self-Quenching Periodic-Duty Pulse Reactor (A.S. Kochenov, G.G. Kiknadze; SOOBSHCHENIYA AKADEMII NAUK GRUZINSKOY SSR, No 1, Oct 83).....	75
Annihilation Acceleration Of Macroparticles For Controlled Nuclear Fusion (V.V. Gorev; DOKLADY AKADEMII NAUK SSSR, No 1, 1984)....	76
Measurement of Parameters Of High Current Electron Beam By Scattering (A.F. Aleksandrov, S.Yu. Galuzo, et al.; DOKLADY AKADEMII NAUK SSSR, No 1, 1984).....	76
Asymptotic Analysis Of Gas Compression Processes In Spherical Symmetry (A.M. Svalov; ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI, No 6, Nov-Dec 83).....	77
OPTICS AND SPECTROSCOPY	
Effect of Neutron and Gamma Radiation On Optical Spectra Of Glass (I.Kh. Abdukadyrova; IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK, No 5, Sep-Oct 83).....	78



Regular Procedure For Constructing Array Of Nonredundant Aperture Masks For Seeing Through Turbulent Atmosphere (L.Ye. Kopilovich; DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI, No 10, Oct 83).....	78
Interband Exciton Light Absorption In Thin Films In The Presence Of Resonant Laser Radiation (G.M. Arutyunyan; IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA, No 5, Sep-Oct 83).....	79
Electron Paramagnetic Resonance and Optical Spectrum Of Cobalt Impurity Ions In $\alpha$ -LiIO <sub>3</sub> (A.A. Mirzakhanyan, A.K. Petrosyan, et al.; IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA, No 5, Sep-Oct 83).....	80
New Class of S-Polarized Nonlinear Surface Waves (A.I. Lomtev; OPTIKA I SPEKTROSKOPIYA, NO 6, Dec 83)...	80
Apparatus Based On Holographic Focusing Diffraction Grating For Measurement Of Diffraction Efficiency of Three-Dimensional Image Holograms (T.N. Paramonova, Yu.N. Denisyuk; OPTIKA I SPEKTROSKOPIYA, No 6, Jun 83).....	81
Method Of Measuring Number Of Space-Coherent Optical Radiation Modes (A.A. Leshchev; OPTIKA I SPEKTROSKOPIYA, No 6, Dec 83)...	82
Amplification Of Ultrashort Optical Pulses During Forward Stimulated Scattering (V.A. Gorbunov; OPTIKA I SPEKTROSKOPIYA, No 6, Dec 83)...	82
Time Correlation Between Processes Of Photon Emission And Iron Or Ni-Cr-Mo Steel Fracture (A.A. Tupik, N.P. Valuyev, et al.; DOKLADY AKADEMII NAUK SSSR, No 4, Oct 83).....	83
Higher-Order Resonances In Intrinsic And Scattered Microwave Radiation From Sea Surface (I.V. Chernyy, V.S. Etkin; DOKLADY AKADEMII NAUK SSSR, No 4, Oct 83).....	83
Feasibility Of Compensating Radiation Field Of Sources By Means Of Phase-Conjugate Mirror (F.V. Bunkin, D.V. Vlasov; DOKLADY AKADEMII NAUK SSSR, No 4, Oct 83).....	84

Raman Scattering Of Light in Alkali-Metal Phosphate Melts (A.F. Banishev, Yu.K. Voron'ko, et al.; DOKLADY AKADEMII NAUK SSSR, No 3, Jan 84).....	85
Newly Discovered Effect of Interaction Of Optical Radiation and Glass (L.B. Glebov, V.G. Dokuchayev, et al.; DOKLADY AKADEMII NAUK SSSR, No 3, Jan 84).....	85
Features of Mechanism By Which Scintillation Light Pulses Form in High-Speed Organic Scintillators (N.Z. Galunov; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 4, Oct 83).....	86
Optoacoustic Laser Spectroscopy of Molecular Gases And Its Use For Producing Submillimetric Laser Radiation and For Q-Switching of CO <sub>2</sub> -Lasers (V.A. Bugayev, E.P. Shliteris; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 4, Oct 83).....	87
Spectroscopic Study of Recombination Processes In Weakly Ionized Decaying Plasmas of Inert Gasses (Review) (V.A. Ivanov, N.P. Penkin; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 84).....	87
Measurement of Gain In CO <sub>2</sub> Plasma In Waveguide Discharge Channel With Transverse Radio-Frequency Excitation (S.P. Vol'skaya; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 84).....	88
Experimental Study of Speckle Structure Formed Upon Passage Of Laser Radiation Through Optically Thin Layers Of Frosted Glasses (N.I. Shcherbakova, N.A. Voyshvillo; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 84).....	88
Characteristics Of Absorption Of Optical Resonance Radiation In Spectral Line (M.B. Gornyy, D.L. Markman, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 84).....	89
Relation Between Intensity and Width of Spectral Lines in Radiation From Homogeneous Optically Dense Plasma (G.V. Ovechkin; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 84).....	90
Non-Contact Measurement of Thickness With Shock Waves Excited By Laser (L.S. Korochkin, A.N. Khodinskiy, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 84).....	90

Laser-Pulse Spectrofluorometer (V.T. Koyava, A.M. Sarzhevskiy, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 84).....	91
Source of Optical Pumping For High-Resolution Spectroscopy With Semiconductor Laser (L.A. Budkin, O.G. Okhotnikov, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 1, Jan 84).....	92
Alignment of Multiplet Components Of Atomic Levels In Collisions (A.G. Petrashen, V.N. Rebane, et al.; OPTIKA I SPEKTROSKOPIYA, No 5, Nov 83).....	92
Ion of Hydrogen Molecule In Strong Magnetic Field (V.K. Khersonskiy; OPTIKA I SPEKTROSKOPIYA, No 5, Nov 83).....	93
Influence That Conditions Of Recording And Reconstruction Have On Angular Selectivity Of Holograms (A.D. Gal'pern, A.A. Paramonov; OPTIKA I SPEKTROSKOPIYA No 5, Nov 83).....	94
Three-Wave Parametric Mixing of Waves With Broad Angular Spectra (A.G. Arutyukyan, G.P. Dzhotyan, et al.; OPTIKA I SPEKTROSKOPIYA, No 5, Nov 83).....	94
Influence That Optical Inhomogeneity Of Agglomeration Boundary Between Glasses Has On Laser Emission Characteristics (A.G. Murzin, N.A. Soldakova, et al.; OPTIKA I SPEKTROSKOPIYA, No 5, Nov 83).....	95
Influence Of Reabsorption On Spectrum Of Superradiation and Stimulated Emission of Dye Laser With Longitudinal Excitation (L.A. Ageyev, V.K. Mikoslavskiy; OPTIKA I SPEKTROSKOPIYA, No 5, Nov 83).....	95
Raman Light Scattering By Crystals With Laminar Structure (V.F. Shavanov, S.Ya. Vetrov, et al.; OPTIKA I SPEKTROSKOPIYA, No 5, Nov 83).....	96
Optical Constants Of Natural Aerosols In Infrared Spectral Region (V.K. Sonchik; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, No 11, Nov 83).....	97
Theory Of Unsteady Stimulated Temperature Scattering of Light (F.V. Bunkin, K.I. Volyak, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 12, Dec 83).....	97
Self-Modulation of Light Waves In Homeotropically Oriented Nematic Liquid Crystals (S.M. Arakelyan, L. Ye. Arushanyan, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 12, Dec 83)	98

Experimental Study of Strong Nonlinear-Optics Effects in Liquid Crystals (S.D. Darbin, S.M. Arakelyan, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 12, Dec 83).....	99
Burnout Of Gap With Complex Shape By Coherent Picosecond Pulse Train (A.K. Rebane, R.K. Kaarli, et al.; OPTIKA I SPEKTROSKOPIYA, No 3, Sep 83).....	99
Orientation Effect With Exposure To Linearly Polarized Nonresonant Light. II. Quantum Mechanical Description (K.K. Boyarskiy, Ye.N. Kotlikov; OPTIKA I SPEKTROSKOPIYA, No 3, Sep 83).....	100
Peculiarities Of Holographic And Speckle Interferograms Produced Upon Registration Of Object Light Field In Fourier Plane (I.S. Klimenko, V.P. Ryabukho, et al.; OPTIKA I SPEKTROSKOPIYA, No 3, Sep 83).....	100
Diffraction Efficiency Of Volume Phase Microholograms (A.P. Yakimovich; OPTIKA I SPEKTROSKOPIYA, No 3, Sep 83).....	101
Quality of System That Produces Three-Dimensional Raster-Holographic Image (A.D. Gal'pern, Yu.N. Denisyuk, et al.; OPTIKA I SPEKTROSKOPIYA, No 3, Sep 83)	
Frequency Tuning of Four-Photon Mixing Emission in Birefringent Fiber-Optics Light Guide (Ye.M., Dianov, E.A. Zakhidov, et al.; PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 23, Dec 83).....	102
Resonant Magnetic Rotation Of Polarization of Laser Emission By Surface-Adsorbed Br <sub>2</sub> Molecules (V.I. Baraulya, I.M. Beterov, et al.; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84).....	103
Time Characteristics Of Light Wave Level in Fluctuating Wind (Ye.A. Monastyrnyy, G.Ya. Patrushev, et al.; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84)	
Nature And Properties Of Short-Wave Luminescence of Polymethyne Dyes (V.I. Popechits, M.P. Samtsov; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84).....	104
Theory Of Stimulated Raman Scattering By Polaritons in Cubic Crystals In Case of Pumping with Broad Angular Spectrum (G.P. Dzhotyan, L.L. Minasyan; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84).....	105



Influence Of Dimensional Quantization On Optical Properties Of Thin Metal Films (R. Gerkhardt, A.S. Kondrat'yev, et al.; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84).....	106
Internal Field Of Water Droplet On Laser Emission Wavelengths in 3.39-10.6 $\mu$ m Band (V.S. Loskutov, G.M. Strelkov; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84).....	106
Diffraction of Light By Dielectric Layer With Sine-Wave Corrugation of Boundary. II. Discussion of Special Solutions (Yu.P. Udoyev; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84)...	107
Calculating Radiation From Converging Edge Of Planar Optical Waveguide. Geometric Optics Approximation (K.F. Yeskin, A.N. Grishmanovskiy, et al.; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84).....	108
Monochromatic Point Scattering Function of Kinoform Objective Lens (V.Ya. Levin, S.I. Soskin; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84).....	109

#### OPTOELECTRONICS

Method Of Reconstructing Two-Dimensional And Multidimensional Images From Phase Of Their Fourier Spectrum (Yu.M. Bruk, L.G. Sodin; DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСKIYE NAUKI, No 10, Oct 83).....	110
Double Scattering Background In a CW Lidar (A.V. Sinyavskiy; IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA, No 5, Sep-Oct 83).....	111
Dependence Of Efficiency Of Thermionic Energy Converter On Optical Properties of Electrodes (A.V. Bulyga; DOKLADY AKADEMII NAUK BSSR, No 9, Sep 83)..	111
Phase Methods of Controlling Spectrum of Generated Radiation (A.P. Voytovich; DOKLADY AKADEMII NAUK BSSR, No 9, Sep 83).....	112
Effect of Amplitudinal Anisotropy on Polarization Control Of Laser Radiation (S.D. Dem'yantseva, G.A. Lazarev, et al.; ZHURNAL PRIKLADNOY SPEKTROSKOPII, No 4, Oct 83).....	112
Holographic Lens For Optical Correlator (G.B. Semenov, S.N. Koreshev, et al.; OPTIKA I SPEKTROSKOPIYA, No 5, Nov 83).....	113

Gunn-Domain Doppler Effect (V.B. Sandomirskiy, A.V. Sheverev; PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI, No 23, Dec 83).....	113
Light Emission of Dielectric Under Effect of Rapidly Alternating Field (V.V. Chernyshev; PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI, No 23, Dec 83).....	114
Influence That Diffusion Motion of Atoms Has on Double Radio-Optic Resonance Signal Shape (M.B. Gornyy, D.L. Markman, et al.; PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI, No 24, Dec 83).....	114
Profiling Radiation Intensity With Phase Control (N.N. Rozanov, V.Ye Semenov; PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI, No 24, Dec 83).....	115
Optimum Linear Filtration of Images (Yu.V. Stolyarov; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84)	115
Properties Of Reflective Elements in Optically Coherent Image Processing Systems (Ye.A. Dudkina, K.I. Dudkin; OPTIKA I SPEKTROSKOPIYA, No 1, Jan 84).....	116

#### PLASMA PHYSICS

Resonance and Edge Amplification of An Electric Field in A Plasma Resonance Layer and Acceleration of Particles at Plasma Inhomogeneities (G.A. Askar'yan, S.V. Bulanov; PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI, No 20, Oct 83).....	117
Oscillations In A Plasma Lens And Their Influence On a Focused Ion Beam (I.S. Gasanov, I.M. Protsenko; PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI, No 20, Oct 83).....	117
Channeled Helicon Waves In Magnetized Solid-State Plasma (Z.K. Yankauskas; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA, No 1, Jan 84).....	118
Influence That Processes Of Electron Detachment From Negative Ions Have On Mechanism Of Current Flow In Medium-Pressure Glow Discharge (V.V. Breyev, S.V. Dvurechenskiy, et al.; ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI, No 6, Nov-Dec 83).....	119

- Source of Radiation on  $L_{\alpha}$  Wavelength Of Hydrogen For Diagnosing  
High-Temperature Plasma  
(S.A. Vatishche, V.S. Burakov, et al.; PIS'MA V ZHURNAL  
TEKHNICHESKOY FIZIKI, No 23, Dec 83)..... 120

## THEORETICAL PHYSICS

- Localized Waves In Nonhomogeneous Media  
(A.Vl. Gurevich, R.G. Mints; USPEKHI FIZICHESKIKH NAUK,  
No 1, Jan 84)..... 122

- Spectral Theory of Two-Dimensional Open Resonators With  
Dielectric Inclusions  
(A.Ye. Poyedinchuk; DOKLADY NAUK UKRAINSKOY SSR,  
SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE  
NAUKI, No 1, Jan 84)..... 123

- Diffraction Of Electromagnetic Waves By Grating of Oblique Strips  
(S.N. Vorob'yev, L.N. Litvinenko, et al.; DOKLADY AKADEMII  
NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE  
I TEKHNICHESKIYE NAUKI, No 1, Jan 84)..... 124

- Quantum Scattering And Electromagnetic Wave Scattering By Unbounded  
Obstacles  
(Ye.M. Il'in; VESTNIK LENINGRADSKOGO UNIVERSITETA, No 3,  
Aug 83)..... 124

- Multiple Wave Scattering By Inhomogeneous Medium Perturbations Which  
Encompass The Vicinity of the Caustic for the Case of  
Oblique Propagation  
(N.N. Zernov; VESTNIK LENINGRADSKOGO UNIVERSITETA,  
No 3, Aug 83)..... 125

- Nonlinear Dynamics of Resonance-Type Instability In High-Density  
Electron Beam; Analytical Solution  
(M.V. Kuzelev, V.A. Panin; IZVESTIYA VYSSHIKH  
UCHEBNYKH ZAVEDENIY: FIZIKA, No 1, Jan 84)..... 125

- Exact Solutions To Systems Of Equations Describing Radiation  
Transfer With Discontinuity At Boundary Between Two Media  
(Ye.S. Andreyev, M.Yu. Kozmanov, et al.; ZHURNAL  
VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI,  
No 1, Jan 84)..... 126

- Numerical Solution Of Equations Of Three-Dimensional Mixing Layer  
(E.A. Gershbein, S.V. Peygin; ZHURNAL VYCHISLITEL'NOY  
MATEMATIKI I MATEMATICHESKOY FIZIKI, No 1, Jan 84)..... 126

- Mathematical Modeling of Metal Vaporization By Electron Beam  
(S.S. Filippov, B.N. Chetverushkin, et al.; DOKLADY  
AKADEMII NAUK SSSR, No 4, Oct 83)..... 127

Existence Of Solution Of System Of Equations Describing Filtration Gas Combustion (Yu.M. Layevskiy; ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI, No 6, Nov-Dec 83).....	128
Solitons In Appreciably Nonlinear One-Dimensional Chain (Ye.G. Vedenova, L.I. Manevich, et al.; ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI, No 6, Nov-Dec 83).....	128
Alternative Method Of Describing Crystallization Kinetics (A.Ya. Malkin, I.A. Kipin, et al.; INZHENERNO- FIZICHESKIY ZHURNAL, No 1, Jan 84).....	129

#### THERMODYNAMICS

Cooling OF Semiinfinite Body Under Conditions Of Nonlinear Heat Transfer At Surface (Yu.I. Babenko; INZHENERNO-FIZICHESKIY ZHURNAL, No 4, Oct 83).....	130
Conditions Of Filtration Burning Of Porous Condensed Systems With Multiple Passage Of Reaction Wave (O.S. Rabinovich, S.N. Krasil'shchikov, et al.; INZHENERNO-FIZICHESKIY ZHURNAL, No 1, Jan 84).....	130

#### MATHEMATICS

Stable Method For Solving Linear Programming Problem With Approximate Data (A.N. Tikhonov, A.A. Tyutin, et al.; DOKLADY AKADEMII NAUK SSSR, No 5, Oct 83).....	132
Two-Phase Methods Of Solving Canonical Problem Of Linear Programming (R. Gabasov, F.M. Kirillova, et al.; DOKLADY AKADEMII NAUK BSSR, No 9, Sep 83).....	132
Economical Multiplication Of Boolean Equations (Yu.I. Zhuravlev, N.M. Platonenko; ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI, No 1, Jan 84).....	133
Sequential Method Of Minimizing Nonlinear Function On Simplex (V.S. Mikhalevich, N.N. Redkovskiy, et al.; DOKLADY AKADEMII NAUK SSSR, No 3, Jan 84).....	133

UDC 534.1

EXCITATION OF SHOCK VIBRATIONS AT RESONANCE IN TWO ULTRASONIC MAGNETOSTRICTIVE TRANSDUCERS FACING ONE ANOTHER

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 28, No 1, Jan 84  
(manuscript received 4 Mar 83) pp 25-27

KLUBOVICH, V.V., corresponding member, BSSR Academy of Sciences, VAGAPOV, I.K. and SAKEVICH, V.N., Institute of Solid State and Semiconductor Physics, BSSR Academy of Sciences, Vitebsk branch

[Abstract] Nonlinear interaction between waveguides-concentrators and the resulting changes in their resonance characteristics can be utilized for stabilization of shock vibrations during ultrasonic treatment as a technological process. Two magnetostrictive transducers facing one another are considered for this purpose, and the feasibility of generating stable longitudinal resonance modes is demonstrated theoretically. Both transducers are treated as viscoelastic bars vibrating longitudinally, each under a harmonically alternating axial load force and each under a constant axial compression, with force feedback through a sensor, an amplifier, and a delay line. The corresponding equations of motion are formulated in terms of dynamic self- and mutual compliance operators relating the respective harmonic load forces to the axial displacements. Since the transducers do not move together, they can be regarded each separately with an elastic constraint. The authors thank V.K. Astashev and M.Ye. Gerts for discussion of the results. Figure 1; references 4 Russian.

[89-2415]

UDC 543.232

THERMOOPTICAL EXCITATION OF SURFACE ACOUSTIC WAVES IN SOLID

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 6, Nov-Dec 82  
(manuscript received 26 Feb 81) pp 836-837

KRYLOV, V.V. and PAVLOV, V.I., Chair of Physics, Moscow State University imeni M.V. Lomonosov

[Abstract] Excitation of surface acoustic Rayleigh waves by an intensity-modulated narrow light beam is for the first time analyzed theoretically. The analysis is based on the equation of motion, the linearized equation of

state of stress and strain including thermal effects, and the linearized equation of heat balance disregarding viscosity and heat conduction. The efficiency of thermo-optical excitation has been calculated for the case of 100% harmonic modulation in an adiabatic process. The results agree roughly with experimental data on excitation of 30 MHz Rayleigh waves in aluminum by a CO<sub>2</sub>-laser (wavelength  $\lambda = 10.6 \mu\text{m}$ ), namely that the efficiency is  $\eta \sim 2 \cdot 10^{-6} I_0\%$  ( $I_0$  - intensity of unmodulated light beam, in  $\text{W/cm}^2$ ) for  $k_R \alpha = \sqrt{2}$  ( $k_R$  - Rayleigh wave number,  $\alpha$  - characteristic width of Gaussian laser beam) or  $\eta \sim 10^{-2}$  with resonant attenuation of laser spectrum and conversion losses in a wedge. References 9: 4 Russian, 5 Western.  
[92-2415]

UDC 534.26

#### WAVEGUIDE ISOLATION OF FLEXURAL WAVES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 6, Nov-Dec 82  
(manuscript received 18 Jun 81) p 792-798

KOVINSKAYA, S.I. and NIKIFOROV, A.S.

[Abstract] Uniform flexural vibrations are considered in a system consisting of two plates separated by a lossless elastic interlayer serving as isolation between the lower base plate and the upper load plate. The dispersion equation for the propagation constant of flexural waves in such a system is derived from the equations of harmonic motion for the two plates and longitudinal vibrations for the interlayer, in a rectangular system of coordinates with one axis parallel to the surfaces and one axis normal to them, with boundary conditions of contact on both sides of the interlayer. This dispersion equation is analyzed and the input impedance is calculated for four special cases: 1) no load plate; 2) identical base and load plates; 3) infinitely stiff load plate; 4) almost perfectly soft load plate. The third case is most interesting from the standpoint of vibration isolation in the low-frequency range. In the practical situation the stiffness of the load plate is not infinite but high and there is some loss in the interlayer. Figure 1, references 5: 2 Russian, 3 Western.  
[92-2415]

UDC 534.87

#### NOISE FIELD OF SOURCES CONCENTRATED NEAR FACES OF WEDGE

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 6, Nov-Dec 82  
(manuscript received 13 Oct 81) pp 785-791

KARNOVSKIY, A.M.

[Abstract] The noise field of uncorrelated statistically stationary random noise sources near the faces of a wedge is analyzed, the wedge having one rigid face and one soft face. The space correlation function for such a field is calculated using a cylindrical system of coordinates and a spherical one.



The noise sources are assumed to be distributed over (concentrated within) an infinitesimally narrow cuneiform layer. The distance of this layer from the wedge face is introduced as a small parameter for asymptotic expansion of the field function. Considering that an array of point sources near the soft face is equivalent to an array of dipole sources and that an array of point sources near the rigid face does not emphasize higher-order modes, the far-field space characteristics are calculated for each case. These characteristics are found to be quite different, with a much stronger correlation than in the case of surface noise in a half-space. Figures 3, references 6 Russian. [92-2415]

UDC 534.222.1

#### PHASE-CONJUGATE REFLECTION IN SOUND BEAMS VIA FOUR-PHONON MIXING WITH THERMAL WAVES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 6, Nov-Dec 82  
(manuscript received 18 Jan 81) pp 743-745

BUNKIN, F.V., VLASOV, D.V., ZABOLOTSKAYA, Ye.A. and KRAVTSOV, Yu.A.,  
Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences

[Abstract] Phase conjugation in sound beams by a thermal nonlinearity is analyzed for the general case of opposing acoustic pump waves with different amplitudes and including dissipation of acoustic energy. The weak acoustic signal wave is assumed to propagate in a direction at an arbitrary angle to that of both pump waves. The propagation of the excited conjugate echo wave is described by the corresponding wave equation and heat transfer equation. Temperature dependence of the acoustic velocity and absorption of sound in the medium are taken into account. Solution of this system of equations yields the pressure amplification in the conjugate wave along the interaction space and is then reduced to a single algebraic equation for the phase conjugation gradient. Calculations have been made for small incidence angles. Figures 3, references 2: 1 Russian, 1 Western. [92-2415]

UDC 534.833

#### EFFICIENCY OF WAVELENGTH-THICKNESS VIBRATION DAMPER COATING

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 6, Nov-Dec 82  
(manuscript received 23 Feb 81) pp 737-742)

BOCHKAREV, V.M., STEPANOV, V.B. and TARTAKOVSKIY, B.D., Institute of  
Acoustics imeni N.N. Andreyev, USSR Academy of Sciences

[Abstract] The performance of a vibration damper coating of thickness comparable with the wavelength of vibrations it absorbs is analyzed, taking into account vibration modes generated because of its finite thickness and

the resulting edge effect. The frequency range is considered within which the coating becomes one of wavelength thickness while the bar or plate to which it has been bonded remains thin relative to long strain waves propagating at high velocity through the substrate material. Accordingly, the loss coefficient and the efficiency of such a damper are evaluated for the important case of a coating impedance much lower than the substrate impedance. The problem is solved for a flexural incident wave producing a displacement in the coating whose vector has a longitudinal component and a transverse shear component. The wave number is assumed to be independent of the coating parameters and the displacements at the coating-substrate bond are given. First the strains in the coating are calculated assuming zero losses. Then the resultant dissipation function is evaluated on the basis of these strains and known component loss coefficients. The frequency characteristics of the resultant damping coefficient for flexural waves and of the flexural wave number are found to depend on the coating parameters, namely its thickness as well as density and modulus of elasticity, with the damping coefficient peaking at some antiresonance frequency and the wave number increasing monotonically. The results of calculations are brought into fairly close agreement with experimental data on coating of steel, after curve fitting of data and correction of the calculations by including rotational inertia and shear. Figures 5, references 5: 4 Russian, 1 Western. [92-2415]

UDC 534.24

#### RELATION BETWEEN LATERAL DISPLACEMENT OF ULTRASONIC BEAM AND ATTENUATION COEFFICIENT FOR NORMAL WAVES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 29, No 5, Sep-Oct 83  
(manuscript received 23 Sep 81) pp 715-716

SVIRIDOV, Yu.B., Institute of Mathematics with Computer Center, MSSR Academy of Sciences

[Abstract] A relation is established between the lateral displacement of an ultrasonic beam at a fluid-solid boundary and the attenuation coefficient for a normal wave which this beam excites. Solution of the dispersion equation, by the perturbation method, yields both these variables as functions of the wave number and other acoustic parameters. The attenuation coefficient is assumed to be smaller than the propagation constant in the fluid. Two cases are considered, first an isotropic solid half-space bordering on the fluid and then a solid plate immersed in the fluid. References 10: 6 Russian, 4 Western. [91-2415]

## DIRECTIVITY OF RADIATION FROM FLABELLATE INTERDIGITAL CONVERTER OF SURFACE ACOUSTIC WAVES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 29, No 5, Sep-Oct 83  
(manuscript received 20 Apr 83) pp 708-710

KOBA, S.I.

[Abstract] The amplitude distribution of a surface acoustic wave over the aperture of a flabellate interdigital converter  $U(z) = U_0 \left[ 1 + 2 \frac{\sin^2 \frac{Nz}{2} \cdot \cos^2 \frac{(N+1)z}{2}}{\sin^2 z} \right]$  ( $N$ -number of electrode pairs,  $z = \pi [1 - f(1 - ky)/f_0]$ ,  $f$ -frequency of harmonic incident vibration,  $f_0$ -frequency of acoustic synchronism,  $y$ -longitudinal coordinate in aperture,  $k = (L_1 - L_2)/\lambda_0$ ,  $L_1$  and  $L_2$  respectively larger and smaller dimensions of converter along  $x$ -coordinate,  $\frac{1}{2}\lambda_0$ -space pitch of electrodes in  $y=0$  section,  $W$ -converter aperture) can, after transformation to  $U(z) = U_0 \frac{\sin^2 \frac{(2N+1)z}{2}}{\sin^2 z}$ , be approximated as  $U(z) = (2N+1)U_0 \text{sinc}^2 \frac{(2N+1)z}{2}$  for  $N \gg 1$  and  $z < \pi$ . The accuracy of this approximation is estimated here and the estimates verified by measurements made at  $f = f_0 = 30$  MHz in three different converters. The width of the sound beam is accordingly  $B = 4f_0/kf(2N+1)$ . The author thanks A.P. Zapunnyy and V.V. Ovsyannikov on the staff of Kiev Polytechnic Institute for assistance in preparing and performing the experiments. Figure 1, table 1, references 2 (Russian). [91-2415]

UDC 534

## POLARIZATION OF ULTRASOUND DURING PASSAGE THROUGH BONDARY BETWEEN MAGNETICALLY INACTIVE MEDIUM AND EQUATORIALLY MAGNETIZED MEDIUM

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 29, No 5, Sep-Oct 83  
(manuscript received 15 Mar 82) pp 702-704

BABUSHKIN, G.A., Institute of Metallurgy, Ural Science Center, USSR Academy of Sciences

[Abstract] Polarization of elastic waves during passage from a nonmagnetic medium to an equatorially magnetized one has been analyzed, considering all types of elastic waves. Solution of the corresponding boundary-value problem for quasi-longitudinal and quasi-transverse waves has revealed that the ellipticity (ratio of semiaxes) of polarization and the orientation (rotation angle) of the major axis relative to the refraction vector do not depend on the incidence angle at the boundary between media but depend only on the gyrotropy of the magnetic medium, this gyrotropy being characterized by effective antisymmetric components of the elasticity tensor and these components depending on the magnetic field intensity as well as on the ultrasound frequency. These conclusions apply to isotropically elastic crystals, hexagonal crystals, and polycrystals magnetized along a principal crystallographic axis during propagation of ultrasound in a direction perpendicular to that axis. The author thanks K.B. Vlasov for discussion of the results. Figures 2, references 1 Russian. [91-2415]

## TRANSITORY RADIATION OF SOUND BY MASS SOURCE MOVING ABOVE UNEVEN SURFACE

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 29, No 5, Sep-Oct 83  
(manuscript received 19 Apr 82) pp 673-677

PAVLOV, V.I. and SUKHORUKOV, A.I., Chair of Acoustics, Moscow State University  
imeni M.V. Lomonosov

[Abstract] A quantitative evaluation is made of acoustic radiation which a mass or heat source emits while moving at subsonic velocity through a homogeneous medium parallel to an uneven surface. Unevenness of the surface is assumed to be the only cause of this radiation. The complete system of equations describing the motion of the medium in acoustic waves is reduced to the Helmholtz equation for the Fourier potential component. The corresponding boundary-value perturbation problem is formulated first in the approximation of an even surface with the potential expressed in terms of MacDonald functions and then for various forms of surface unevenness: exponentially damped or sinusoidally periodic function of the space coordinate parallel to the direction of motion of the source, or random function of this coordinate with normal distribution of asperity heights. Directional diagrams are plotted for radiation at low frequency (50 Hz) and for total radiation at all frequencies. Figures 3, references 4 Russian.  
[91-2415]

## CHANGING DIRECTION OF PROPAGATION OF SURFACE ACOUSTIC WAVES BY MEANS OF PERIODIC UNEVENNESS

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 29, No 5, Sep-Oct 83  
(manuscript received 14 May 82) pp 700-702

ALYAKNA, Yu.Yu. and PLESSKIY, V.P.

[Abstract] Reflection of surface acoustic Rayleigh waves by a periodic unevenness is analyzed, considering an array of parallel creases oriented at some arbitrary angle to its front and back edges. The amplitude of waves is assumed to be uniform not along the creases but along the front edge and variable in the direction normal to it. The edge effect is included in derivation of the dispersion equation from the Bragg condition for the wave number and the wave vector of incident waves. Expressions are obtained for the transmission coefficient and the reflection coefficient in two cases, reflected waves leaving the array through the back edge or through the front edge respectively, the calculations here not being applicable to the case of glancing incident wave. Figures 2, references 3 Russian.  
[91-2415]

DETERMINATION OF PRESSURE GAIN IN ACOUSTIC ANTENNA ARRAY FROM MEASUREMENTS  
IN FRESNEL ZONE

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 29, No 5, Sep-Oct 83  
(manuscript received 30 Apr 81, after correction 21 Apr 82) pp 615-618

ZEMLYAKOV, V.L. and NIKESHIN, S.G.

[Abstract] The pressure gain in an acoustic transmitter antenna is calculated from measurements made in the Fresnel zone, this gain being defined as the ratio of array efficiency to transducer-element efficiency in the direction of the main lobe. The calculations are made by ray expansion of a spherical wave and expansion of the pressure field in a negative-power series with respect to distance. The accuracy of this gain calculation depends on the number of series terms retained as well as on the error of acoustic pressure measurements. Figures 4, references 9 Russian.  
[91-2415]

UDC 681.883.677

## SYNTHESIS OF ANTENNAS FOR LOCATION NEAR REFLECTING SURFACES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 29, No 5, Sep-Oct 83  
(manuscript received 26 May 82) pp 603-607

GALANENKO, V.B., KRASNYY, L.G. and MATSYUPURA, V.T., Kiev Polytechnic  
Institute imeni Semicentennial of Great Socialist October Revolution

[Abstract] The statistical-mean radiation pattern of an acoustic receiver antenna with random variance of the sensitivity of elements is synthesized according to the criterion of maximum output signal-to-interference ratio, in the case of an antenna located near reflecting surfaces. The synthesis is based on using two plane incident waves, a signal wave arriving from one direction and an interference wave arriving from another one. The mean sensitivity of the antenna elements is set at a level which ensures not only optimum extraction of the useful signal but also efficient suppression of the diffraction effect. The general algorithm of minimizing the deviation from the optimum amplitude-phase distribution is applied first to an antenna with fixed angles of signal and interference incidence, then to an antenna near a soft plane surface perpendicular to the antenna axis. The synthesized radiation pattern, with a maximum in the signal direction and a minimum in the interference direction in the first case, is found to have a major lobe with notches the depth of which depends on the distribution of mean sensitivity. A comparison with synthesis of an antenna for a given radiation pattern reveals that both algorithms are interrelated and yield essentially the same result. Figures 3, references 4: 3 Russian, 1 Western.  
[91-2415]

## DEPENDENCE OF ACOUSTIC PROPERTIES OF SOUND ABSORBING FIBROUS MATERIALS ON THEIR STRUCTURE

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 29, No 5, Sep-Oct 83  
(manuscript received 18 May 82) pp 598-602

VORONINA, N.N., Scientific Research Institute of Structural Physics

[Abstract] The performance of sound absorbing structures is characterized by two acoustic parameters: the dimensionless wave impedance (referred to the wave impedance of air) and the propagation constant. Both parameters can be defined as complex quantities whose real and imaginary parts have been evaluated for various materials. On the basis of experimental data, semiempirical relations have been established describing these parameters as functions of the density and of the fiber thickness, in the case of fibrous materials, as well as their frequency characteristics. The results given in this study pertain to fiberglass, mineral cotton wool, and nylon fiber. Figures 5, table 1, references 9: 5 Russian, 4 Western.  
[91-2415]

UDC 534.874

## CROSS SPECTRUM OF RADIATED NOISE SIGNAL AND SIGNAL REFLECTED BY MULTILAYER SEA BED

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 30 Jul 82) pp 137-138

KRASNOBOROD'KO, V.V., Institute of Oceanology imeni P.P. Shirshov, USSR Academy of Sciences

[Abstract] The cross spectrum of a radiated noise signal and the signal reflected by a multilayer sea bed is calculated on the basis of the cross-correlation function already known for such a case. Inasmuch as this function is not an even one, the cross spectrum is a complex quantity. Stratification of the sea bed results in a series of frequency gaps or interference fringes in the cophased (real) part of the complex spectrum, these gaps becoming sharper as the Rayleigh parameter decreases and as the reflection coefficient at the interlayer boundaries increases. References 2 Russian.  
[90-2415]

## PARAMETRIC EXCITATION OF TRANSVERSE ACOUSTIC SLOT WAVES IN SOLIDS BY MEANS OF MICROWAVE ELECTRIC FIELD

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 22 Jul 82) pp 132-134

BONDARENKO, T.I. and BURLAK, G.N., Kiev State University imeni T.G. Shevchenko

[Abstract] It is demonstrated theoretically that a high-frequency electric field can produce transverse acoustic waves propagating along the boundary between two electrostrictive crystals. When the frequency  $\Omega$  of these acoustic waves approaches the pumping frequency  $\Omega_p$  of the electric field, parametric resonance of oppositely propagating waves occurs at their frequency and at the difference frequency  $2\omega_p - \Omega$ . Resonance of surface acoustic waves differs from resonance of volume acoustic waves, on account of the different interaction dynamics and different boundary conditions. The phenomenon is analyzed here for two identical crystals with cubic symmetry, contiguous except for a slot between them, and an electric field parallel to the surface. The corresponding Maxwell equations and elasticity equations, including electrostriction, are formulated in a system of coordinates coinciding with the system of crystallographic axes. These equations, with coefficients varying periodically in time, reduce to an infinite system of coupling equations. This system yields the spectral components and then the dispersion equation. Solution of the latter, by a numerical method, has revealed a transmission window in the spectrum within the range of parametric instability. This result can be useful for producing controllable filters. References 5 Russian.

[90-2415]

## STUDY OF SEA BED UNEVENNESS WITH AMPLITUDE-MODULATED SIGNAL

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 29 Jun 82) pp 118-121

SHEYNFEL'D, I.V., Scientific Research Institute of Radiophysics

[Abstract] Unevenness of the sea bed was studied experimentally from the scientific research ship "Poisk" during its voyage on the Atlantic Ocean in 1979. A sinusoidally amplitude-modulated acoustic signal was used for measurements, the statistical characteristics of the echo signal envelope after scattering by the sea bed and the dependence of those characteristics on the modulation frequency having been analyzed later on a Plyurimat digital computer. The algorithm of the data evaluation process included squaring the envelope amplitude and the unmodulated signal amplitude, then averaging these squares at a given modulation frequency and calculating the square of the percent modulation of the pressure wave. The main advantage of using an amplitude-modulated signal rather than a frequency-modulated one for determining the rms height of sea bed asperities is that it does not require vertical shifting of the transmitter-receiver set or using two transmitter-receiver sets at different depths. The author thanks L.S. Dolin and B.F. Kur'yanov for helpful discussions. Figures 3, references 6 Russian.

[90-2415]



# RESONANCE SCATTERING OF SOUND WAVES BY ELASTIC SPHERICAL SHELL IMMERSSED IN FLUID

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 18 Mar 82) pp 89-95

PODDUBNYAK, A.P., Institute of Application Problems in Mechanics and Mathematics, UkSSR Academy of Sciences

[Abstract] The problem of scattering of plane acoustic waves by a thin spherical elastic shell immersed in a fluid is solved by the Wigner R-matrix method with use of the Mittag-Leffler expansion. The conditions for resonance are established, considering the Breit-Wigner form of S-matrix elements in the vicinity of R-matrix poles. Calculations for the steady-state problem have been made for a steel shell with a 0.05 thickness-to-radius ratio in water. Calculations for the transient problem are made with a Fourier integral transformation of the echo signal. The author thanks Ya.S. Podstrigach and N.D. Veksler for helpful comments. Figures 4, references 21: 14 Russian, 7 Western.  
[90-2415]

UDC 534.21

# DISPERSION CURVES FOR NORMAL WAVES IN CYLINDRICAL SHELL UNDER CONDITION OF SPACE COINCIDENCE WITHIN VICINITY OF CRITICAL FREQUENCIES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 23 Jul 82) pp 83-88

MUZYCHENKO, V.V., PANIKLENKO, A.P. and RYBAK, S.A., Institute of Acoustics imeni N.N. Andreyev, USSR Academy of Sciences

[Abstract] Scattering of normal plane acoustic waves by an infinitely long thin elastic cylindrical shell immersed in a fluid is analyzed in terms of dispersion curves for quasi-flexural, quasi-longitudinal, and quasi-shear waves at arbitrary angles of incidence. Expressions are derived for frequencies and angles of space coincidence within the vicinity of the shell's critical frequencies, on the basis of a system of three corresponding differential equations of motion in a cylindrical system of coordinates. The matrix of differential operators is assumed to be symmetric, in accordance with the Betti theorem, and deviations of the shell's median surface from its undeformed state are taken into account in terms of normal, longitudinal and circumferential displacements. The resulting dispersion equation is solved easier numerically than analytically. It has been solved for a steel shell in water. Calculations were made not only for the zeroth-order ( $n=0$ ) and fundamental ( $n=1$ ) modes but also for higher-order ( $n \geq 2$ ) modes. Here the results for quasi-flexural waves are discussed.

The results for quasi-longitudinal and quasi-shear waves are basically analogous. In the case of quasi-flexural waves the condition for space coincidence is found to be satisfied at any incidence angle and the coincidence frequency to be close to the critical frequency, however, while in the other two cases space coincidence occurs only within limited ranges of incidence angles. Figures 4, references 4 Russian.  
[90-2415]

UDC 534.21.1

CALCULATING HORIZONTAL REFRACTION OF SOUND WAVES BY SHALLOW SEA BY  
PERTURBATION METHOD

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 24 Jul 82) pp 79-82

KRAVTSOV, Yu.A., KUZ'KIN, V.M. and PETNIKOV, V.G., Institute of Physics imeni  
P.N. Lebedev, USSR Academy of Sciences

[Abstract] The perturbation method is applied to horizontal refraction of sound waves by shallow sea, assuming that the parameters of the medium (depth, acoustic velocity, reflection coefficient of the sea bed) vary in the horizontal plane slowly enough for the acoustic field to be regarded as the superposition of noninteracting adiabatic modes. Analytical expressions are derived for the horizontal refraction angle and the group delay time or path length as well as for their successive variations. The general results are applied to two specific cases, a waveguide with zero vertical velocity gradient and a boundary-layer waveguide at the sea bed with the vertical velocity gradient a function of the horizontal coordinates. The variable sea depth corresponding to an uneven sea bed profile is taken into account in both cases. The second case demonstrates the dependence of horizontal refraction on the hydrological conditions in the medium. The method of analysis and calculation can be extended to deep sea. Figure 1, references 9: 8 Russian, 1 Western.  
[90-2415]

UDC 534.231

RADIATION FROM EQUATORIAL SPHERICAL ZONE WITH PULSATING SURFACES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 11 Aug 82) pp 66-73

KELEBERDENKO, S.B., OBOZHENKO, I.L. and SKRYNCHENKO, V.A.

[Abstract] Radiation of an acoustic field from an equatorial zone of a spherical shell with pulsating inside and outside surfaces is analyzed as that from a Helmholtz resonator for underwater research. The geometrical parameter of such a zone, ratio of half-width to radius, is allowed to vary

from 0 to 1. The boundary-value problem for the corresponding Helmholtz equation is solved for the case of cophased pulsations of both surfaces. The method of least squares yields slowly converging successive approximations, a part of the problem thus being to determine the minimum sufficient number of terms  $N_0$ , in variational expansions, necessary for sufficient accuracy. The original boundary-value problem is, therefore, replaced by an equivalent minimization problem for the quadratic velocity-potential functional, the velocity potential being assumed to satisfy the Sommerfeld condition of radiation. The conventional minimization procedure yields a system of  $2(N+1)$  linear algebraic equations in  $2(N+1)$  unknowns. The algorithm of its numerical solution is the basis of the RING program, written in FORTRAN for a BESM-6 high-speed computer. This program calculates both resistive and reactive components of the radiation impedance of both surfaces, the directional characteristics, and the concentration factor as functions of  $ka$  ( $k$  - wave number,  $a$  - radius of sphere) and of  $y=h/a$  ( $h$  - half-width of zone). The results obtained by this numerical method agree closely with the known analytical solution for a spherical Helmholtz resonator with circular polar holes ( $y=0.7-1$ ). Figures 6, tables 3, references 8: 7 Russian, 1 Western.

[90-2415]

UDC 620.178.4:534.8

# SIMULATION OF VIBRATORY PROCESSES IN DAMPED STRUCTURES WITH TEMPERATURE-FREQUENCY CHARACTERISTICS OF VIBRATION ABSORBING MATERIALS TAKEN INTO ACCOUNT

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 24 Jul 82) pp 18-22

BUVAYLO, L.Ye. and IONOV, A.V.

[Abstract] A model is constructed which describes vibratory processes in structures with proportional damping on the basis of classical relations for prototype-to-model scale-down, these relations being extended here to include both temperature dependence and frequency dependence of the absorption characteristics of the material. These characteristics are defined in terms of the complex modulus of elasticity  $E^*=E(1+j\beta_E)$  and the complex modulus of shear  $G^*=G(1+j\gamma_G)$  with respective loss coefficients  $\beta_E$  and  $\gamma_G$ . The model is further extended to multilayer structures, specifically double-layer structures consisting of a beam with vibration absorbing cladding and triple-layer "sandwiches" consisting of a filler between two reinforcing sheaths. The components of the resultant modulus of rigidity of such composite structures are plotted as functions of temperature and frequency in a three-dimensional system of coordinates. Typical such diagrams are shown for structures with "Agat" as cladding (vibration absorbing) material and for symmetric structures with polyvinyl acetate as viscoelastic filler material, model experiments having been scaled to the 0-30°C temperature range and the 3-3000 Hz frequency range. Into account has been taken some permissible model error. Figures 4, references 4 Russian.

[90-2415]

## NATURAL VIBRATIONS OF MEMBRANE IN INFINITELY LONG WAVEGUIDE

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 9 Jul 82) pp 14-17

BELINSKIY, B.P., Leningrad State University imeni A.A. Zhdanov

[Abstract] The existence of natural vibrations in an infinitely long plane acoustic waveguide with stiff walls and a thin flexurally vibrating membrane across the center section is demonstrated analytically, by solution of the corresponding Helmholtz equation for boundary conditions of zero transverse pressure gradient at the waveguide walls and Meixner condition at the nodal points. The pressure field is calculated as a sum of harmonic components with an exponential decay factor. The relation between wave thickness of the membrane and relative width of the waveguide channel is established which can reduce the determinant of boundary-contact coefficients to zero. In the case of steel walls and steel membrane with water as filler there can exist natural modes symmetric or antisymmetric with respect to the median line when the waveguide has a rectangular cross section but not when it has a circular one. No natural vibrations can occur when the membrane is an absorbing medium. The results can be extended to semiinfinite waveguides, also to membranes freely rather than rigidly inserted. The author thanks D.P. Kouzov for attention to this study. Figure 1, references 3 Russian. [90-2415]

UDC 535.33:621.375.8

## RELATION BETWEEN PRESSURE PULSE GENERATED IN OPTOACOUSTIC RECEIVER AND INTENSITY OF STIMULATING LASER PULSE

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 26, No 11, Nov 83 (manuscript received 29 Dec 82) pp 8-11

PONOMAREV, Yu.N., PONOMAREVA, S.B. and TIKHOMIROV, B.A., Institute of Optics of the Atmosphere, Siberian Department, USSR Academy of Sciences

[Abstract] In previous research, the authors have considered the way that the number of vibrationally excited gas molecules depends on the characteristics of an intense laser pulse passed through the gas, and have qualitatively analyzed the optoacoustic method of laser spectroscopy at high radiation intensities. In this paper, an analysis is made of the time behavior and amplitude of the acoustic signal generated in the cell of an optoacoustic spectrometer upon nonlinear unsteady absorption of a laser pulse by the gas being studied, and an expression is derived for the parameter characterizing nonlinearity of absorption. A solution is found for the equation that describes the pressure pulse that arises when a molecular gas in a closed cell of an optoacoustic receiver absorbs the energy of an incident light pulse, assuming that the energy of the laser radiation is uniformly distributed over the cross section of the beam, that the beam radius is much less than the

radius of the receiver, that the length of the cell is much greater than the radius of the receiver, that the pressures in the investigated gas are high enough to disregard losses of vibrational energy upon collisions between excited molecules and the walls of the cell and losses due to spontaneous emission from the excited vibrational state, that the light pulse is square-wave in shape, and that its duration is greater than the time of rotational relaxation in the gas, but much less than the times of vibrational-translational and thermal relaxations. Based on the solution of this equation an expression is derived for the dimensionless ratio B of the number of excited molecules produced by the laser pulse in the mode of nonlinear absorption to the number for the mode of linear absorption. The parameter B characterizes the nonlinearity of absorptivity of the medium being studied by optoacoustic laser spectrometry. Measurements on a mixture of  $\text{H}_2\text{O}-\text{N}_2$  at two pressures with  $\text{H}_2\text{O}$  content of less than 2% in the mixture show that the value of B, and hence the absorption saturation efficiency in the  $\text{H}_2\text{O}$  line decreases: a) with an increase in detuning from exact resonance; b) with increasing total gas pressure. References 7: 5 Russian, 2 Western.  
[129-6610]

#### EXCITATION OF PRESSURE PULSE IN WATER WITH EXPLOSIVE VAPORIZATION OF SURFACE LAYER

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 23, 12 Dec 83 (manuscript received 1 Jul 83) pp 1442-1445

VITSHAS, A.F., GRIGOR'YEV, V.V., KORNEYEV, V.V., SENTSOV, Yu.I., TERENT'YEV, A.P. and UL'YANOV, K.N.

[Abstract] Considerable research is now being done on interaction of intense light pulses with the surface of liquids. This paper is devoted to theoretical and experimental investigation of the optoacoustic effect in water in the mode of developed vaporization. Previous experimental research has been done under conditions close to the threshold of evaporation. The sole exception is a paper by Giovanneschi et al. (APPL. PHYS. LETT., Vol 36, 1980, p 882). However, no data are given on the time behavior of power density  $dW/dt$ , required for comparing the measured energy dependences of subsurface water pressure  $p(W)$  with calculations. Therefore the authors measure the pressure amplitude at a distance of 0.5 cm from the surface of the water for pulse energy densities  $W$  from 0.1 to 30  $\text{J}/\text{cm}^2$ . Radiation on a wavelength of 10.6  $\mu\text{m}$  was focused in a spot on the surface with area ranging from 1 to 6 sq. cm. Emission power was registered by a detector with time resolution of 50 ns. Pressure was measured by a flat lead zirconate titanate disk 12 mm in diameter and 0.3 mm thick fastened with conductive epoxy cement to a long brass rod. The other plate of the piezoelectric element was connected to a metal tube coaxial with the rod by a silver layer sputtered on the insulator surface. In the range of  $W = 0.3-1.5 \text{ J}/\text{cm}^2$ , a square-law relation of  $p(W)$  is observed in evaporative interaction between radiation and water. Energy density  $W_1 \approx 1.5 \text{ J}/\text{cm}^2$  is sufficient to convert a layer of water with thickness  $\mu^{-1} \cdot 10^{-3}$  cm thick to vapor ( $\mu$  is the

coefficient of absorption of radiation in water). At this point, the square-law dependence of  $p(W)$  becomes linear. At  $W \sim 30 \text{ J/cm}^2$ , a brightly luminescent plasma region can be seen above the water surface. A theoretical model is proposed that satisfactorily describes the experimental data at pressures up to about 200 atmospheres. Figures 2, references 9: 7 Russian, 2 Western.

[117-6610]

#### SOUND FIELD OF TURBULENT WAKE

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 24, 26 Dec 83 (manuscript received 2 Sep 83) pp 1506-1510

LAMSHEV, L.M. and SKVORTSOV, A.T.

[Abstract] An examination is made of turbulent fluid motion that arises behind a solid in a homogeneous flow at constant velocity much less than the speed of sound in the fluid. Turbulent movement in the wake, like any unsteady motion of a compressible fluid, will be accompanied by acoustic emission. At any predetermined velocity, the intensity of this emission is determined solely by the drag of the solid, and is not explicitly dependent on viscosity, shape of the solid, dimensions of the wake or other factors. The pressure in the sound wave emitted by the wake is found by using Lighthill's relations for generation of sound by a turbulent flow. It is assumed that pulsations are correlated in the turbulent region where emission arises. An expression is derived for the energy emitted by this region per unit of time in all directions. It is shown that acoustic emission of the wake is maximum in the direction of flow, and zero in the direction perpendicular to the flow. Figure 1, references 4: 3 Russian, 1 Western. [114-6610]

#### INVESTIGATION OF OPTO-ACOUSTIC PHASE CHARACTERISTICS OF FIBER-OPTICS LIGHT GUIDES WITH DIFFERENT STRUCTURES

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 12, Dec 83 pp 2429-2432

BERSHTEYN, I.L., GUR'YANOV, A.N., GUSOVSKIY, D.D., DIANOV, Ye.M., ZAYTSEV, Yu.I., KRAVTSOV, Yu.A., LEONOV, V.I., MALEKHANOV, A.I., MINCHENKO, A.I. and STEPANOV, D.P., Physics Institute imeni P.N. Lebedev, USSR Academy of Sciences

[Abstract] The paper gives the results of two independent series of experiments in which an investigation was made of the opto-acoustic characteristics of single-mode fiber optics light guides immersed in liquid in which acoustic pressure was generated with resultant nearly uniform deformation of the specimens. The opto-acoustic characteristics of the light guides are characterized by the change in phase  $\Delta\phi/\phi$  of the light wave under the influence of acoustic pressure  $p$ . The quantity  $\mu = \Delta\phi/\phi p$ , or in

differential form  $\mu = \phi^{-1} \partial \phi / \partial p$ , is called the phase opto-acoustic sensitivity. Here  $\phi = \beta Z \approx k_0 n Z$  is the phase advance in the fiber-optics light guide,  $\beta$  is the mode constant of propagation,  $k_0$  is the wave number of light in vacuum, and  $Z$  is the length of the waveguide. In the first series of experiments, the phase opto-acoustic sensitivity on a wavelength of  $0.63 \mu\text{m}$  in coiled light guides was measured in a quasi-standing acoustic field in the frequency band from tens of hertz to several kilohertz, and in a quasi-traveling field in the band from 3-5 to 20 kHz. The values of  $\mu$  for the same light guides with lacquer and polyamide coating were found to be rather large and comparatively close. It was found that the coil forms have a considerable effect on the measurements, increasing the phase shift by one or two orders of magnitude over measurements without coil forms. The second series of experiments was done on the same light guides with two kinds of polymer coatings: a one-layer coating of P-610 polyamide with outside diameter of  $650 \mu\text{m}$ , and a two-layer coating with inner layer of dimethylsiloxane rubber  $50\text{--}70 \mu\text{m}$  thick, and an outer layer of 4MB fluorocarbon polymer  $700\text{--}500 \mu\text{m}$  in diameter. Measurements were made in a uniform acoustic field in the frequency band of  $0.4\text{--}10 \text{ kHz}$ . Light guides  $8\text{--}10 \text{ m}$  in length were formed into toroidal coils  $5\text{--}12 \text{ cm}$  in diameter suspended from thin threads. It was found that phase shift is independent of coil diameter and frequency. The uniform hard polyamide coating gave a greater increase in phase shift than did the coating with a soft rubber damper layer. Figures 2, references 8 Russian.

[141-6610]



UDC 537.226.4

ANOMALIES OF SPIN-LATTICE RELAXATION IN CRYSTALS WITH DEFECTS NEAR POINTS OF STRUCTURAL PHASE TRANSITIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 48, No 1, Jan 84 pp 197-199

LEVANYUK, A.P., MOSHCHINSKIY, B.V. and SIGOV, A.S.

[Abstract] Anomalous slowdown of spin-lattice relaxation of electron-paramagnetic centers in some uniaxial ferroelectric crystals with phase transition of the second kind is explained by the mechanism of S-defects (defects causing structural distortions which correspond to the order parameter also above the phase transition point). This anomaly is opposite rather than analogous to spin-lattice relaxation of nuclear-paramagnetic centers in crystals with structural phase transition. On the basis of the spin Hamiltonian, the probability of spin transition between levels  $n$  and  $n+2$  is estimated in the second order of perturbation theory. Assuming relaxational dynamics of the order parameter, its thermal fluctuations are found to contribute a nonsingular slowdown of spin-lattice relaxation near the  $T_C$  point and frozen-in "random field" defects are found to contribute a singular slowdown of spin-lattice relaxation at  $T - T_C$ . For more precise calculations and correct interpretation of experimental evidence, it is necessary to include the effect of far-range dipole forces particularly significant in uniaxial ferroelectric crystals. References 8: 1 Russian, 7 Western.

[120-2415]

UDC 538.566

NONLINEAR SCATTERING OF RADIO WAVES BY METAL OBJECTS

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 142, No 1, Jan 84 pp 131-145

SHTEYNHLEYGER, V.B.

[Abstract] Nonlinear scattering of radio waves by metal structures with resulting harmonic and intermodulation interference is analyzed from both theoretical and empirical standpoints, disregarding nonlinear effects associated with the nonlinear dependence of the electric or magnetic

polarization vector on respectively the electric or magnetic field intensity in the wave propagating medium. First are considered nonlinear characteristics of metal-oxide-metal contacts where the thin oxide film separating two metal surfaces has properties approximately those of a dielectric or a high-resistivity semiconductor. Tunneling has been found to be the principal mechanism of charge carrier transfer through such a contact with a sufficiently thin film, the contact having usually a "cubic" or sometimes an "integral sign" current-voltage characteristic at 300 K and usually an S-form or sometimes a "cubic" current-voltage characteristic at 77 K. Most significant interference is caused naturally by the third harmonic and also by third-order intermodulation at the difference frequency  $2f_1 - f_2$ , associated with a power-law power response  $P_{\text{nonlin}} = k P_{\text{fund}}^m$  where  $m \approx 3$  according to empirical evidence. Nonlinear scattering is analyzed on the basis of an equivalent electric circuit where the load across a source of sinusoidal emf consists of an external resistance in series with a nonlinear contact element shunted by a capacitance. The corresponding first-order differential equation of the third degree with respect to voltage for voltage as a function of time, an Abel equation of the first kind not generally solvable in quadratures, is solved approximately by methods in the theory of nonlinear oscillations. The effective scattering area, a practical measure of linear or nonlinear scattering in the Fraunhofer zone, is then evaluated for a nonlinear dipole vibrator. It is found to depend on the radiation power density, approximately proportional to the  $(m-1)$ th power of the latter (with  $m \approx 2.5$  at radiation power densities of the order of  $1 \text{ W/m}^2$ ). On this basis is derived an expression for the power of a radio signal at the receiver antenna of nonlinear radars. This power is an inverse-power function of the distance  $r$  from antenna to object, namely  $P \propto r^{-8}$  when  $m = 3$  and  $P \propto r^{-7}$  when  $m = 2.5$  ( $P \propto r^{-4}$  in a linear radar with  $m = 1$ ). Further studies on the subject of nonlinear scattering should deal with its frequency characteristics and with the effect of real ("dirty") rather than ideal contacts at metal surfaces. The author thanks Yu.B. Kobzarev for helpful discussions of the problem, also S.A. Akhmanov and M.A. Miller for reading the manuscript with comments. Figures 7, references 38: 15 Russian, 23 Western.

[96-2415]

UDC 621.350.592

# ANGLE DEPENDENCE ON FREQUENCIES OF POLAR OPTICAL PHONONS IN TlSe AND ITS STRUCTURAL ANALOGS

Baku DOKLADY AKADEMII NAUK AZERBAYDZHANSKOY SSR in Russian Vol 39, No 9, Sep 83 (manuscript received 6 Oct 82) pp 40-43

ALIYEV, R.A., ALLAKHVERDIYEV, K.R., Academician SALAYEV, E.Yu., SARDARLY, R.M., SAFAROV, N.Yu. and SHTEYNShRAYBER, V.Ya., Institute of Physics

[Abstract] The theory of polar optical phonons and the angle dependence of their frequency in TlSe, TlS, TlInSe<sub>2</sub>, based on reflection spectra in the infrared range, is extended to the case where more than one phonon can

appear and decay within a reflection band. The frequency of infrared active phonons in these crystals was calculated as a function of the angle between reflecting surface and optical axis. Measurements were made on crystals grown in quartz tubes by the Bridgman method. Reflection spectra recorded in s-polarized light were found to be the same at different orientations of the reflecting surface. Reflection spectra recorded in p-polarized light were found to change appreciably with change of the orientation angle. Only frequencies of transverse optical phonons were found to depend on the angle, frequencies of longitudinal optical phonons remaining constant. Experimental data were evaluated according to the theory of long-wave optical vibrations for uniaxial crystals. No transmission band split by an absorption band exists in the high-frequency range, according to the angular pattern of lattice reflection, which is attributable to a high attenuation coefficient for longitudinal optical phonons. Figures 2, references 9: 3 Russian, 6 Western.  
[115-2415]

UDC 539.401.2.678

#### EFFECT OF ELECTRIC FIELD ON MECHANICAL STRENGTH OF GaSe SINGLE CRYSTALS

Baku DOKLADY AKADEMII NAUK AZERBAJDZANSKOY SSR in Russian Vol 39, No 9, Sep 83  
(manuscript received 27 Feb 82) pp 32-35

ABASOV, S.A., ELMIRA JALAL KIZI, ALIYEVA, M.Kh. and KURBANOV, M.A.,  
Institute of Physics

[Abstract] The effect of a constant electric field on the mechanical strength and the life of single crystals was studied experimentally in a test stand where mechanical stresses in specimens could be maintained at constant levels. The specimens were plates cut from a large ingot (single crystal). The electric field was applied through metal contact tabs, its intensity varied successively up to 17.6 kV/mm. The tests were performed at room temperature. The life was found to decrease exponentially with increasing field intensity, a normal trend. The mechanical strength was found to vary nonmonotonically with increasing field intensity, first dropping over the 0-4.4 kV/mm range and then rising over the 4.4-8.8 kV/mm range before dropping again with further increase of the field intensity. A similar anomaly had been revealed in the temperature of mechanical strength. Here this anomaly is attributed to diffusional hardening of the material within the 4.4-8.8 kV/mm range. The increase of strength in this range is attributed to two processes taking place simultaneously. One process is heating with attendant heat treatment and dissipation of thermal acceptors. The other process is double injection of carriers from the contacts in a strong electric field, which changes the charged state and fills the r-centers (Ga levels) as well as the Coulomb force. This is not possible below 4.4 kV/mm and above 8.8 kV/mm, interatomic bonds being perturbed in the first case and also the structure being disorderd in the second case. A comparison with the current-voltage characteristics indicates that their quadratic or cubic

range corresponds to the range of increasing mechanical strength. Article was presented by Academician (AzSSR Academy of Sciences) G.B. Abdullayev. Figures 3, references 9 Russian. [115-2415]

UDC 534.143+548.732

#### ACOUSTOOPTICS OF X-RAYS

Tashkent IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK in Russian No 5, Sep-Oct 83 (manuscript received 24 Mar 83) pp 63-68

BALAKHANOV, M.V., PUSTOVOYT, V.I., RADZHABOV, R.U. and KHABIBULLAYEV, P.K., Institute of Nuclear Physics, UzSSR Academy of Sciences

[Abstract] Scattering of x-rays by acoustic phonons in crystals during excitation of a noise phonon flux thermodynamically at equilibrium is analyzed from the standpoint of the dynamic diffraction theory, emphasis being put on the differences with the conventional acoustooptic effect attributable to lower frequencies and smaller amplitudes. The structural peak and the diffusional peak are calculated from known relations for the intensity of scattering in each mode, assuming that the Laue condition is satisfied. Interaction of x-rays and an acoustic wave is considered, the conditions for a diffraction peak being determined by the relations between location of that peak and angular dimensions of the structural peak. Experiments were performed in crystals of photosensitive piezoelectric semiconductors with phonon generation. Rectangular or variable-shape voltage pulses with amplitudes up to 800 V were applied to 6-60  $\mu\text{m}$  thick CdS crystals at repetition rates up to 800 Hz. The electron concentration was  $(1.3-4.5) \cdot 10^{14} \text{ cm}^{-3}$  and the electron mobility, according to saturation of the current-voltage characteristics, was approximately  $220 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ . The data were processed both integrally and differentially in time. The results reveal sharp anisotropy of scattering, evident in the dependence of scattering intensity on the angle of crystal rotation and the resulting lobar scattering pattern. Structural scattering varies exponentially and diffusional scattering varies linearly with increasing amplitude of the applied voltage. According to the dependence of the spectral density of phonon generation on the concentration of charge carriers, the phase of the scattering effect changes upon transition from the structural range to the diffusional range. An analogous effect of decaying harmonics upon application of an electric field was revealed by Brillouin scattering. Figures 3, references 8: 5 Russian, 3 Western. [108-2415]

## ENERGY LEVELS OF SELENIUM IMPURITY IN GERMANIUM

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 39, No 3, 10 Feb 84 (manuscript received 13 Dec 83) pp 126-129

OSIP'YAN, Yu.A., PROKOPENKO, V.M. and TAL'YANSKIY, V.I., Institute of  
Solid State Physics, USSR Academy of Sciences

[Abstract] The established view that selenium impurity in germanium constitutes a two-charge donor with energy levels 0.14 and 0.28 eV above the bottom of the conduction band is contradicted by experimental evidence. It has been suggested that the two levels correspond to two states of selenium in the Ge-lattice. Here an experimental method of resolving this contradiction is proposed which involves irradiation of natural germanium with thermal neutrons and then analyzing the selenium produced in the process. Natural germanium contains  $^{70}\text{Ge}$ ,  $^{72}\text{Ge}$ ,  $^{74}\text{Ge}$  and  $^{76}\text{Ge}$  isotopes which undergo conversion upon capture of thermal neutron:  $^{70}\text{Ge}$  converts into  $^{71}\text{Ge}$  acceptor in 12 days upon K-decay,  $^{74}\text{Ge}$  converts into  $^{75}\text{As}$  in 82 min upon  $\beta$ -decay,  $^{76}\text{Ge}$  converts into  $^{77}\text{As}$  in 12 h upon  $\beta$ -decay and  $^{77}\text{As}$  converts into  $^{77}\text{Se}$  in 38.8 h upon  $\beta$ -decay. For approximately 6 hours after the  $^{71}\text{Ge}$  concentration has become comparable with the  $^{75}\text{As}$  concentration, the  $^{77}\text{Se}$  concentration satisfied the inequality  $N_{\text{As}} < N_{\text{Ge}} < N_{\text{As}} + kN_{\text{Se}}$  over a wide temperature range ( $k=1$  or  $2$  depending on whether Se is a one-charge or two-charge donor). The positions of the energy levels can now be determined from the temperature dependence of the electron concentration during that 6 h period. This was done using ultrapure n-Ge ( $n \sim 2 \cdot 10^{11} \text{ cm}^{-3}$ ) material and bombarding it with thermal neutrons to a final  $^{71}\text{Ge}$  concentration of approximately  $3 \cdot 10^{14} \text{ cm}^{-3}$ . The specimens were then annealed for 12h, one at  $450^\circ\text{C}$  and one at  $500^\circ\text{C}$ , with subsequent slow cooling. Measurements at 77 K (a temperature sufficiently low for deep-level electrons not to be excited) revealed a deep dip in the carrier concentration during the period from 9 hours to 15 hours after the fifth day. The results indicate that selenium is a one-charge donor with a 0.28 eV energy level situated in the Ge-lattice, while the 0.14 eV level evidently corresponds to a selenium atom either in a complex or situated between lattice nodes. Figures 2, table 1, references 6: 4 Russian, 2 Western.  
[180-2415]

## AMPLIFICATION OF TRAVELING MAGNETOSTATIC WAVES BY PARAMETRIC PUMPING

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 39, No 3, 19 Feb 84 (manuscript received 10 Dec 83) pp 124-126

BASHKOVSKIY, A.V. and ZUBKOV, V.I., Institute of Radio Engineering and Electronics, USSR Academy of Sciences, KRUTSENKO, I.V. and MELKOV, G.A., Kiev State University imeni T.G. Shevchenko

[Abstract] An experiment was performed with traveling surface magnetostatic waves in a structure consisting of two parallel microstrip lines isolated from one another on a common Polycor base, both covered with a YIG (yttrium-iron garnet) film on a GGG (gallium-gadolinum garnet) substrate. An open

dielectric pumping cavity resonator at the center of the  $9.6 \mu\text{m}$  thick YIG film on its substrate side was operating in the "parallel" mode, with its magnetic field parallel to the constant external magnetic field, this mode of operation requiring less power than the "transverse" mode. The frequency of surface magneto-static waves on the YIG film (saturation magnetization  $4\pi M_0 = 1750 \text{ Gs}$ , width of resonance line  $2 \Delta H = 0.5 \text{ Oe}$ ) was  $\sim 4.7 \text{ GHz}$  and the pumping frequency was  $\sim 9.4 \text{ GHz}$ , with the intensity of the external magnetic field  $\sim 940 \text{ Oe}$ . Heating of the film was avoided by pumping with pulses of  $20 \mu\text{s}$  duration at a repetition rate of  $50 \text{ Hz}$  rather than with a continuous wave. This experiment for the first time revealed amplification of surface magnetostatic waves, the gain reaching  $16 \text{ dB}$  at a pumping power of  $2.2 \text{ W}$  with  $8 \text{ MHz}$  bandwidth and  $3 \mu\text{s}$  delay time. Amplification occurred in a magnetic field of intensity  $H_0$  corresponding to maximum signal transmission from input to output microstrip line. The amplification mechanism is in many respects analogous to that of microwave amplification by magnetostatic precession modes in ferrite single crystals, namely paramagnetic excitation of various groups of spin waves and their collective oscillation. In addition, there also occurred here generation of waves at precisely the magnetic field intensity  $H_0$  as well as at  $H_0 + 4 \text{ Oe}$ , with attendant emission at pumping power of the order of  $1 \text{ W}$ . Figure 1, references 5 Russian. [180-2415]

UDC 548.736.6

# THE CRYSTALLINE STRUCTURE OF $\text{Na}_5\text{Nd}_4[\text{SiO}_4]_4(\text{OH})$

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 1, 1984  
(manuscript received 24 Jun 83) pp 75-78

MALINOVSKIY, Yu.A., Institute of Crystallography imeni A.V. Shubnikov,  
USSR Academy of Sciences, Moscow

[Abstract] Crystals of the compound studied were synthesized under hydrothermal conditions at  $500^\circ\text{C}$ ,  $1 \text{ kbar}$  in the system  $\text{Na}_2\text{O}-\text{BaO}-\text{Nd}_2\text{O}_3-\text{SiO}_2-\text{H}_2\text{O}$ . A single crystal rolled into a sphere  $0.1 \text{ mm}$  in diameter was used for x-ray diffraction studies to determine the lattice parameters. Determination of lattice parameters and analysis of interatomic vector functions determined that the crystal was of structural type  $4\{\text{NaYSiO}_4\} \cdot \text{NaF}$ . The final formula of the compound was determined by a variety of methods as  $\text{Na}_5\text{Nd}_4[\text{SiO}_4]_4(\text{OH})$ . Tables present the coordinates of the base atoms, interatomic distances and ellipsoids of thermal oscillations. The compound is isostructural with the orthosilicates of Sm, Gd and Y. Figures 2, references 5 Russian. [25-6508]

## NONLINEAR OPTICAL ELECTROREFLECTION IN GERMANIUM AND SILICON

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 1, 1984  
(manuscript received 7 Jul 83) pp 62-65

AKTSIPETROV, O.A. and MISHINA, Ye.D., Moscow State University imeni M.V. Lomonosov, Moscow Institute of Radio Engineering, Electronics and Automation

[Abstract] A study is made of the influence of a constant electric field on the generation of the second harmonic upon reflection of light from the surfaces of germanium and silicon specimens. Reflection was studied in germanium and silicon with various states of the surfaces and semiconductors. Generation of second harmonics was observed upon reflection of the radiation of a pulsed single-mode YAG:Nd<sup>3+</sup> laser at wavelength 1060 nm, pulse length 15 ns, energy density about 20 mJ/cm<sup>2</sup>. The sensitivity of the process of generation of second harmonic reflections to the charge state of the surface as well as surface of the semiconductor and the presence of an oxide film on the surface as well as surface states and adsorbed organic molecules can be used to develop a new method for studying the surface of semiconductor materials: nonlinear optical electroreflection. Figures 3, references 5: 2 Russian, 3 Western.  
[25-6508]

UDC 621.382

## CALCULATING ELECTRIC FIELDS IN SEMICONDUCTOR STRUCTURES WHEN SINGULARITIES ARE PRESENT

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR: SERIYA A FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСKIYE NAUKI in Russian No 12, Dec 83 (manuscript received 5 Jul 83) pp 39-41

KUL'CHITSKIY, V.L., PLAKHOTNYY, V.P., SMOVZH, A.K. and SVECHNIKOV, S.V., corresponding member of the UkrSSR Academy of Sciences, Institute of Semiconductors of the UkrSSR Academy of Sciences, Kiev

[Abstract] Since numerical methods such as finite differences encounter serious difficulties when applied to the mathematical simulation of electric fields in various semiconductor structures with singularities at corner points and boundary condition discontinuities, the precise quantitative analysis of such fields must be based on the analysis of the nature of the singularities as a function of structure geometry and the physical parameters of the inhomogeneity. This paper is a theoretical treatment of the electric field in the photoconductive layer of a distributed photoresist structure, where a periodic system of electrodes is applied on top of the layer. Boundary condition discontinuities of the second kind are present at the edges of the electrodes; the electric field at these points has singularities which manifest in the local heating of the material



of the photoconductive layer in the regions near the contacts. An analytical solution of the resulting boundary value problem using Laplace equations is used to plot the field distribution of the steady-state electric current in the photoconducting layer as a function of the structure's geometry. A comparison with experimental data from simulation trials using electrically conductive paper shows a disparity between theory and experiment of no more than 3% in the determination of the field point potentials. The proposed simulation technique was used to optimize the topology of such a structure and determine the ultimately attainable parameters; it was also applied to the formulation of the problem of heat dissipation in the photoconductive layer through the dielectric substrate to a heat sink. Figure 1, references 8: 7 Russian, 1 Western. [102-8225]

UDC 621.315.592

# PHONON SCATTERING IN A SOLID SOLUTION OF $\text{In}_{1-x}\text{Ga}_x\text{Sb}$

Baku DOKLADY AKADEMII NAUK AZERBAYDZHANSKOY SSR in Russian Vol 39, No 8, Aug 83 pp 21-23

ALIYEV, M.I., Academician of the AzSSR Academy of Sciences, ZEYNALOV, S.A., ARASLY, D.G., ALIYEV, S.A. and RAGIMOV, R.N.

[Abstract] The heat and temperature conductivity in large samples of  $\text{In}_{1-x}\text{Ga}_x\text{Sb}$  is studied as a function of the composition ( $x = 0, 1, 0.05, 0.53$  and  $0.66$ ) for temperatures between 120 and 700 K in order to obtain data on phonon scattering at point defects in the solid solution. At low temperatures, when  $x = 0.5$ , the phonon thermal conductivity is reduced by almost half; this conductivity is proportional to  $T^{-n}$ , and the exponent falls off from 1.3 to 0.8. This indicates the considerable impact of the disordered nature of the solid solution on phonon scattering. The behavior of the thermal resistance plotted as a function of the composition of the samples at 300 K indicates that the indium and gallium atoms have the same effect on phonon scattering. Calculated values of this resistance are lower than the experimental data. The divergence can be accounted for by normal processes: in InSb and GaSb, high frequency transverse phonons make the major contribution to phonon thermal conductivity; in the solid solution, the high frequency phonons experience the greatest scattering at point defects and long-wave phonons make the main contribution to the thermal conductivity. It is well known that N-processes which redistribute the frequencies among the phonons can affect the phonon thermal conductivity. These processes are taken into account in adducing an analytical expression for the phonon thermal resistance. Good agreement between experiment and theory is observed here when the initial temperature conductivity is taken as  $a_0=1$ . This shows the substantial role played by N-processes in phonon scattering in such solid solutions. Figures 2, references 11: 6 Russian, 5 Western. [131-8225]

SURFACE ELECTROMAGNETIC WAVE DISPERSION ON SEMICONDUCTORS HAVING A PERIODIC RELIEF FORMED WITH EXPOSURE TO INTENSE LASER RADIATION

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 20, 26 Oct 83 (manuscript received 29 Jul 83) pp 1268-1271

BAZHENOV, V.V., BONCH-BRUYEVICH, A.M., LIBENSON, M.N., MAKIN, V.S., PUDKOV, S.D. and TRUBAYEV, V.V.

[Abstract] Surface polaritons or surface electromagnetic waves (SEW) can be generated by light at the rough boundary of condensed media with negative permittivity. This effect is specifically seen in the formation of periodic surface structures in an intense laser emission field. Since the formation of so-called double and quadruple periodic surface structures having the same orientation and nearly the same periods remains unexplained, this paper uses sensitive reflexometry to study the kinetics of the growth of a double surface structure on germanium and indium antimonide with exposure to p and s-polarized 20-ns pulses at 1.06 micrometers. The phenomenon is explained taking into account the contribution of the resulting periodic relief of the surface to the frequency dispersion and splitting of the surface polariton wave. The proposed explanation is based on the fact that in the general case, there is not just one, but rather several surface polaritons at the same frequency, having different wave vectors at the rough separation boundary between two media, as contrasted to the flat boundary case. For the double period surface structure studied experimentally in this instance, the characteristic difference in the periods of the two structures was 200 Å. The measured value of this difference increased if not one, but two periodic surface structures were produced in the initial stages of exposure to the radiation, where these structures correspond to the propagation of SEW's in opposite directions; this latter fact is also explained by the theory put forward here. References 9: 3 Russian, 6 Western.  
[16-8225]

HIGH EFFICIENCY pAlGaAs-pGaAs-nGaAs PHOTOVOLTAIC SOLAR CELLS WITH EFFICIENCIES OF 19% (AM 0) AND 24% (AM 1.5)

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 20, 26 Oct 83 (manuscript received 25 Jul 83) pp 1215-1254

ANDREYEV, V.M., LARIONOV, V.R., RUMYANTSEV, V.D., FEDOROVA, O.M. and SHAMUKHAMEDOV, Sh.Sh., Physics and Engineering Institute imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] This paper compares the photoelectric performance of solar photocells using epitaxial layers of nGaAs doped with tin and tellurium as well as slight amounts of aluminum added during the growing of the layers. The structures were produced on nGaAs substrates doped to  $N_D = (0.7 - 2) \cdot 10^{18} \text{ cm}^{-3}$  with an area of  $5 \text{ cm}^2$ . The optimum doping depth of the p-n

junction relative to the heteroboundary is 3 to 4 micrometers. The parameters of the photocells are summarized in tabular forms for tests of more than 2,000 cm<sup>2</sup> of such structures. The major parameters which were varied were: 1) The kind of donor impurity (Sn or Te); 2) The level of doping of the nGaAs layer; 3) The Al content in the melt when growing the n-layer. The table includes results of studies of individual photocells under a simulator for solar radiation outside the atmosphere (AM 0) and solar illumination under natural conditions (AM 1.5), where the direct and scattered solar radiation density was 94 mW/cm<sup>2</sup>. The following conclusions are drawn: 1) A high efficiency is attainable using these epitaxial structures doped with Sn (5 to 10 at.% in the melt) and Te (saturating the nGaAs with a concentration of  $N_D = 1 \cdot 10^{18} \text{ cm}^{-3}$ ); no clear advantage is demonstrated for either Sn or Te; 2) Slight additions of Al to the melt increase the no-load voltage and the operational working load range. Efficiencies of 19% (AM 0) and 24% (AM 1.5) were obtained for photocell samples having a high level of production suitability and good reproducibility of the parameters. The authors are grateful to M.G. Kagan for his useful discussions and Zh.I. Alferov for his attention to the work. Table 1, References 5: 4 Russian, 1 Western. [16-8225]

#### ANISOTROPIC CAPTURE OF TWO NATURAL DEEP CENTERS DURING LIQUID PHASE EPITAXY OF GALLIUM ARSENIDE

Leningrad PIS'MA V ZHURNAL TEKHNIKESKOY FIZIKI in Russian Vol 9, No 20, 26 Oct 83 (manuscript received 28 Jun 83) pp 1221-1224

CHIKICHEV, S.I. and KALUKHOV, V.A., Institute of Semiconductor Physics, Siberian Department of the USSR Academy of Sciences, Novosibirsk

[Abstract] GaAs epitaxial films grown from the liquid phase have two deep acceptor centers with ionization energies of  $E_V + 0.04 \text{ eV}$  (the "A" center) and  $E_V + 0.71 \text{ eV}$  ("B"). The influence of substrate orientation and growth temperature on the concentration of A and B centers in undoped layers of GaAs is studied where the GaAs is grown from one solution on two substrates with orientations of (111) A and (111) B, forming a plane parallel gap 1 mm thick. The growth temperature was studied in a range of 780 to 900°C and the cooling rate in all trials was 1°C/min. The deep centers were identified and their concentrations found by relaxation capacitance spectroscopy of the deep levels in a constant capacitance mode. The data are summarized in tabular form and show that the concentration of the A and B centers in films with a (111)A orientation is higher than in (111)B; this difference is preserved against a background of a general reduction in concentration with a decrease in the growth temperature. Possible reasons for the observed orientational anisotropy of the A and B concentrations are discussed and it is noted that the influence of substrate orientation on the concentration of these deep centers shows that nonequilibrium capture actually takes place under the above conditions. Figure 1, references 14: 6 Russian, 8 Western. [16-8225]

## LUMINESCENCE FROM COLOR CENTERS IN YAG-CRYSTALS

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 27, No 1, Jan 84 (manuscript received, after completion, 1 Sep 83) pp 83-87

MARTYNOVICH, Ye.F., TOKAREV, A.G. and GRIGOROV, V.A., Scientific Research Institute of Applied Physics, Irkusk State University imeni A.A. Zhdanov

[Abstract] An experimental study of YAG crystals was made for the purpose of finding color centers in them and determining their optical characteristics. The spectrometric equipment included a xenon lamp and an LGI-501 N<sub>2</sub>-laser, two monochromators (VMS-1 and DMR-4) and two photomultipliers (FEU-79/83), an EZ-4 recording instrument and an S1-70 oscillograph. This study for the first time revealed a center of infrared luminescence with four excitation bands (280, 330, 450, 750 nm) and two fluorescence bands (660, 840 nm). At low temperature (78 K) there was also found another defect, a center of luminescence with three excitation bands (375, 480, 590 nm). Excitation in the 375 nm band resulted also in luminescence with the maximum at a wavelength other (815 nm) than those of maximum luminescence following excitation in the other two bands. At 300 K, moreover, excitation in the other two bands did not result in luminescence. Energy levels and transitions characterizing these centers in YAG crystals have been established on the basis of the data. Figures 5, references 9: 4 Russian, 1 Czech, 4 Western.  
[95-2415]

UDC 621.382.22:620.192.424

## EFFECT OF Ga AND As SUBLAYERS ON INTERPHASE INTERACTIONS AND THERMAL STABILITY OF Pd-GaAs STRUCTURES

Moscow POVERKHNOST': FIZIKA, KHIMIYA, MEKHANIKA in Russian No 1, Jan 84 (manuscript received 18 Jan 83) pp 106-109

ROMANOVA, I.D., MAKSIMOVA, N.K., POTAKHOVA, L.Yu., YAKUBENYA, M.P. and YANOVSKIY, V.P.

[Abstract] A study was made of Pd-GaAs junctions with thin layer of Ga or As between the GaAs and the barrier-forming metal (Pd). Specimens of such junctions were produced on epitaxial n-n<sup>+</sup>-GaAs structures with charge concentration  $n_0 = (5-10) \cdot 10^{15} \text{ cm}^{-3}$  and 10-15  $\mu\text{m}$  thick n-layer. Ohmic contacts were produced by deposition of Pb (0.02  $\mu\text{m}$ ) and Ag (0.48  $\mu\text{m}$ ) with subsequent annealing in a hydrogen atmosphere for 10 min at 550°C. Rectifying contacts 100-500  $\mu\text{m}$  in diameter were produced electrochemically, by deposition of Pd (0.3  $\mu\text{m}$ ) on a sublayer of Ga or As over windows in the SiO<sub>2</sub> mask, and subsequent annealing in a hydrogen atmosphere for 10 min at temperatures ranging from 100 to 600°C in 50°C steps, once at each temperature. A comparative x-ray diffraction analysis of the structures and mass-spectrometry

of secondary ions have revealed that in Pd-As-GaAs structures diffusion of Ga atoms into Pd dominates over diffusion of Pd atoms into the substrate, with attendant formation of  $\text{PdGa}^+$  ions, while in Pd-Ga-GaAs structures Pd and Ga interact just as they do in Pd-GaAs structures. The experiment also involved measurement of current-voltage and capacitance-voltage characteristics, determination of the potential barrier height and the nonideality index  $M = (q/kT)(dV/d \ln I)$  from these curves, and determination of the inverse voltage at fixed inverse current levels of 1.5 and 10  $\mu\text{A}$  respectively. The results confirm the thermal stability of Pd-GaAs diodes with As sublayer, owing to the sharp PdGa-GaAs interface which inhibits diffusion during annealing. Precipitation of excess Ga or As prior to deposition of Pd provides excellent means of controlling the height of the Schottky barrier. Figures 5, references 6: 4 Russian, 2 Western. [148-2415]

UDC 539.26

# USE OF ASYMMETRIC REFLECTIONS IN STUDY OF IMPLANTED GaAs LAYERS BY METHOD OF TWO-CRYSTAL X-RAY DIFFRACTOMETRY

Moscow POVERKHNOST': FIZIKA, KHIMIYA, MEKHANIKA in Russian No 1, Jan 84  
(manuscript received 10 Oct 82) pp 99-105

PRILEPSKIY, M.V. and SUKHODREVA, I.M.

[Abstract] The method of two-crystal x-ray diffractometry is considered for structural analysis of implanted GaAs layers, and the feasibility of using asymmetric reflections for precise determination of the strain profile is examined. Experiments were performed with ion-implanted GaAs layers, bombarded first with  $\text{He}^+$  ions and then with  $\text{Si}^+$  ions, such layers exhibiting a high degree of strain and correspondingly a wide sector of diffraction angles. A comparison of diffraction curves obtained with various asymmetric reflections reveals that changes in the orientation of additional peaks and oscillations follow different trends in each case. Subsequent calculations based on solving the appropriate system of equations for reflection intensity in accordance with laws of geometrical and physical optics, with absorption taken into account, indicate that the number and thicknesses of thin layers with different strains can be determined in this way. A comparison with results based on symmetric reflections indicates that only asymmetric reflections will reveal anisotropic strains in the implanted lattice. The authors thank V.N. Mordkovich for helpful discussion of the results. Figures 2, references 9: 5 Russian, 4 Western. [148-2415]

## ELECTRICAL CHARACTERISTICS OF METAL-DIELECTRIC-SEMICONDUCTOR SYSTEMS PRODUCED ON EPITAXIAL SILICON STRUCTURES WITH VARIOUS DIELECTRICS

Moscow POVERKHNOST': FIZIKA, KHIMIYA, MEKHANIKA in Russian No 1, Jan 84  
(manuscript received 31 Dec 82) pp 80-83

FOMICHEVA, O.F., OTAVINA, L.A., SVERDLOVA, A.M. and KAPSHTAL', G.G., Saratov State University

[Abstract] An experimental study was made of MDS systems with silicon as semiconductor, for the purpose of determining the dependence of their electrical characteristics on the dielectric material. Epitaxial 10  $\mu\text{m}$  thick films of n-Si with electrical resistivity  $\rho \approx 0.8\text{--}1\text{ ohm cm}$  were grown on p-Si substrates with resistivity  $\rho = 10\text{ ohm}\cdot\text{cm}$ , and the field electrode with a surface area of 0.44  $\text{mm}^2$ . In one experiment, three dielectric materials were used:  $\text{SiO}_2$  produced by thermal oxidation,  $\text{SiO}_2$  produced by anodic oxidation, and  $\text{Dy}_2\text{O}_3$ . Both material and deposition process determined the surface condition and the thickness of the space charge region as well as the carrier concentration in it. Switching from high-resistance state to low-resistance state was stable and repeatable in each case. While the total low resistance of the MDS device was within  $10^2\text{--}10^3\text{ ohm}$  and almost independent of the dielectric material, the leakage current in the high-resistance state was highest through thermal  $\text{SiO}_2$  ( $10^4\text{--}10^5\text{ ohm}$ , switching voltage 7 V) and lowest through anodic  $\text{SiO}_2$  ( $10^7\text{ ohm}$ , switching voltage 18-23 V) with  $\text{Dy}_2\text{O}_3$  in the intermediate range. Current-voltage characteristics were measured at frequencies from 20 Hz to 20 kHz with direct current and at the test signal frequency of 0.465 MHz. Also measured were the longitudinal profile of the photoconduction current under illumination levels from 700 to 10,000 lx and the transient voltage response to square-wave pulses of 15-20 ms duration with a repetition rate of 50 Hz. Oscillations were recorded, just as in the case of a CuO dielectric layer, their frequency increasing with increasing amplitude of the bias voltage pulse and decreasing with decreasing temperature over the 20-(-110) $^\circ\text{C}$  range. Figures 4, references 3: 1 Russian, 2 Western.  
[148-2415]

UDC 539.293:537.322

## THERMO-EMF OF SEMICONDUCTOR HETEROJUNCTION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 4, Oct 83  
(manuscript received 20 Apr 83) pp 855-858

LIDORENKO, N.S., corresponding member, USSR Academy of Sciences, BALMUSH, I.I., DASHEVSKIY, Z.M., KASIYAN, A.I. and KOLOMOYETS, N.V.

[Abstract] The thermo-emf and the thermoelectric power of semiconductor heterojunctions are calculated on the basis of the simplest model representing a sharp heterojunction, assuming arbitrarily an n-type semiconductor with narrow forbidden band on one side and a p-type semiconductor with wider forbidden band on the other side. The work function and the electron affinity of the n-type material are respectively smaller and larger than those of the p-type material. Both emf and electric current are described by the



system of equations for electron current density and hole current density, equations of continuity, and the Poisson equation for electric field intensity. The equilibrium distribution of electrons and holes at every point corresponds, in the one-dimensional approximation, to the lattice temperature at that point  $(n,p) \mu_{n,p} Q_{n,p} \frac{1}{T} \frac{dT}{dx}$  ( $n,p$  - electron or hole

concentration,  $\mu_{n,p}$  - electron or hole mobility,  $Q_{n,p}$  - excess mean kinetic energy of electron or hole transport over mean kinetic energy,  $T$  - temperature,  $x$  - longitudinal coordinate). The problem is solved for the appropriate boundary conditions, assuming small thicknesses of both regions, of the order of the diffusion path for minority carriers, so that the longitudinal temperature profile can be approximated as a temperature step. Thermal generation is much weaker in the p-region and can be disregarded, while recombination is much stronger in the p-region with participation of impurity centers. Numerical calculations have been made on this basis for a  $Pb_xSn_{1-x}Te/PbTe$  junction at  $T_0 = 300$  K with donor concentration  $N_d = 10^{18} \text{ cm}^{-3}$ . Figure 1, table 1, references 9: 7 Russian, 2 Czech. [100-2415]

UDC 548.0:535.37

# LUMINESCENCE AND LEVEL STRUCTURE OF IMPURITY CENTERS IN $Y_3Al_5O_{12}:Fe^{3+}$ SINGLE CRYSTALS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 3, Jan 84  
(manuscript received 2 Nov 82) pp 576-580

MEYL'MAN, M.L., KORZHIK, M.V., KUZ'MIN, V.V., LIVSHITS, M.G., BAGDASAROV, Kh.S. and KEVORKOV, A.M., All-Union Correspondence Institute of Structural Engineering, Moscow; Belorussian State University imeni V.I. Lenin, Minsk; Institute of Crystallography imeni A.V. Shubnikov, USSR Academy of Sciences, Moscow

[Abstract] A study was made of optical centers formed by iron ions in garnet (complex oxide) crystals, for the purpose of determining the role of iron impurity ions as luminescence activators, determining the energy structure of such optical centers, and examining some technical aspects of using such single crystals. Specimens of  $YAG:Fe$  single crystals were grown by the process of vertical crystallization from the melt in a molybdenum crucible. Absorption spectra were recorded at 295 K (with PE 554 and Cary 219 photometers), spectra of excited luminescence were recorded at 80 K (with a "Fluorolog" photometer). The results show negligible interaction of activating ions and association of all luminescence bands (except the 255 nm absorption band) with intracenter transitions from ground state to excited state. They also reveal two distinct regions of the absorption spectrum containing transitions of  $Fe^{3+}$  ions in octahedra  $Fe [O]$  and in tetrahedra  $Fe [T]$  respectively, the 255 nm absorption band constituting an exception and possibly a consequence of superposition of  $Fe [O]$  and  $Fe [T]$  charge-transfer bands. The system of optical transitions in  $Fe [T]$  can be interpreted in the conventional approximation of a cubic crystal field, but the positions of quadruplet lower levels are better

estimated on the basis of the Kohler-Amthauer system of equations (J. SOLID STATE CHEM. Vol 28, 1979 p 329). Article was presented by Academician B.K. Vaynshteyn on 19 November 1982. Figures 2, table 1, references 13: 6 Russian, 7 Western.  
[110-2415]

UDC 535.21:621.315.592

# DYNAMICS OF CHANGES IN OPTICAL PROPERTIES OF SEMICONDUCTORS UNDER LASER RADIATION

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 84  
(manuscript received 20 Oct 82) pp 65-69

LOPAREV, A.N., MIN'KO, L.Ya., NASONOV, V.I. and SUKHANOV, Ya.A.

[Abstract] An experimental study of laser action on semiconductors was made for the purpose of exploring the dynamics of changes in their optical properties. Both silicon and germanium were subjected to quasi-steady millisecond radiation pulses from a neodymium laser with power density ranging from below to above the breakdown level. Plane-parallel silicon plates of various thicknesses (1.22-2.06 mm) with polished surfaces and plane-parallel germanium plates of 1.5 mm thickness with either rough or smooth surfaces were irradiated at power density levels from 3 to 300 kW/cm<sup>2</sup>. Fusing of the germanium surface, smooth or rough, began at  $q \sim 60$  kW/cm<sup>2</sup>. Fusion of the germanium surface was complete and microcracking of the smooth silicon surface before its fusion began at  $q \sim 120$  kW/cm<sup>2</sup>. Splitting of the silicon surface began at  $q \sim 300$  kW/cm<sup>2</sup>. Both specular and diffuse components of the reflection coefficient and the absorption coefficient were measured, all found to increase linearly with increasing radiation power density at different rates depending on the material. Before breakdown of the material the total reflection coefficient increases most for polished germanium and least for polished silicon, while the absorption coefficient for silicon increases at a rate which decreases with increasing thickness of the plate. The mechanical action on the surface determines reflection R and absorption A (thus also transmission  $T = 1 - R - A$ ) during the transient period of approximately 1 ms, with reflection generally peaking when the laser pulse peaks (at approximately half of its duration) The authors thank G.P. Yablonskiy for helpful comments. Figures 2, references 6: 5 Russian, 1 Western.  
[61-2415]



# SOLITONS IN DEFORMABLE FERROMAGNETIC WITH ANISOTROPY OF THE 'EASY PLANE' TYPE

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 26, No 11, Nov 83 (manuscript received 23 Dec 82) pp 30-34

ABDULLAYEV, F.Kh. and ABDUMALOKOV, A.A., Tashkent State University imeni V.I. Lenin

[Abstract] Previous research has dealt with the dynamics of magnetic solitons in ferromagnetic chains with anisotropy of the "easy plane" and "easy axis" type. For the low-temperature case where the hypothesis of a gas of quasi-free solitons is applicable, the contribution to the dynamic structural form factor has been calculated. Another problem of interest is the effect that lattice compressibility, and in particular the thermal motion of lattice atoms, has on the motion of magnetic solitons, and in turn the influence that motion of spins has on the lattice deformation field. The authors consider two models relating spins to the field of lattice deformation, and show that in addition to the magnetic soliton, there is a soliton wave of lattice deformation that follows spin interaction. Renormalization of soliton parameters due to interaction with displacements is calculated. The analysis is based on a quasi-one-dimensional planar ferromagnetic of the  $\text{CsNiF}_3$  type. The influence of lattice anharmonicity is studied. References 12: 5 Russian, 7 Western. [129-6610]

UDC 621.315.592

# PARTICULARS OF PHOTOCONDUCTIVITY OF $\text{GaSe<Sn>}$ SINGLE CRYSTALS IN VICINITY OF FUNDAMENTAL ABSORPTION EDGE

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 26, No 11, Nov 83 (manuscript received 17 Aug 82) pp 61-64

KATERINCHUK, V.N. and KOVALYUK, Z.D., Chernovtsy Division of Institute of Problems in Material Science, UkSSR Academy of Sciences

[Abstract] The paper gives the results of a detailed study of the spectra of photoconductivity of  $\text{GaSe<Sn>}$  single crystals at a temperature of 295 K in two configurations: 1. light incident in the direction of crystallographic axis C on a surface with current contacts, and 2. light incident on the rear surface not containing current contacts. The thickness dependence of maximum photocurrent is determined for the second configuration. Considerable anisotropy of photoconductivity is observed only for photocarriers excited on the fundamental absorption edge, i.e. for  $h\nu < E_g$ . This anisotropy is attributed to the formation of excitons in this region of the spectrum. Studies at room temperature show that there is considerable anisotropy of the properties of  $\text{GaSe<Sn>}$  single crystals due to the characteristic laminar structure. Figure 1, references 6: 5 Russian, 1 Western. [129-6610]

## OPTICAL CHARGE EXCHANGE OF DOPANT IN GaAs&lt;Cr&gt;

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 26, No 11, Nov 83 (manuscript received 15 Jun 83) pp 85-89

VAKULENKO, O.V., SKIRDA, A.S. and SKRYSHEVSKIY, V.A., Kiev State University imeni T.G. Shevchenko

[Abstract] An investigation is made of infrared absorption and photoconductivity induced in semi-insulating GaAs<Cr> crystals by laser radiation on a wavelength of 1.15  $\mu\text{m}$ . The specimens had resistivity of  $10^8 \Omega \cdot \text{cm}$  at a temperature of 295 K and chromium concentration of  $10^{17} \text{cm}^{-3}$ . The surface was mechanically polished and etched. Ohmic indium contacts were fused to the specimens and annealed. Photoconductivity was measured on an alternating signal with subsequent synchrodetection. The photoconductivity spectra were analyzed by an IKS-12 spectrometer. Optical photoconductivity was induced by illumination from an LG-126 laser. Measurements were made at temperatures from 85 to 220 K. Intermediate temperatures were held within  $\pm 1^\circ\text{C}$ . The results show amphoteric behavior of the chromium dopant. It is concluded that infrared exposure gives rise to optical charge exchange:  $\text{Cr}^{3+}3d^3 + h\nu \rightarrow \text{Cr}^{2+}3d^4 + \text{Cr}^{4+}3d^2$ . Photoneutralization of  $\text{Cr}^{4+}3d^2$  centers produces additional bands of optical absorption and photoconductivity in the long-wave region. Solutions are found for kinetic equations of these centers that satisfactorily describe experimental results. It is suggested that chromium can be used to compensate both shallow donors and shallow acceptors in GaAs. Figures 4, references 11: 5 Russian, 6 Western. [129-6610]

DETERMINING POSITION OF  $\pi$ - $\nu$  JUNCTION IN IRON-DOPED GALLIUM ARSENIDE EPITAXIAL STRUCTURES

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 26, No 11, Nov 83 (manuscript received 6 Jan 83) pp 89-93

CHERNOV, N.A., VILISOVA, M.D., BAKIN, N.N. and ASANOV, O.M.

[Abstract] When growing epitaxial layers of GaAs:Fe on heavily doped  $n_g^+$  substrates, a  $\pi$ - $\nu$  junction is formed that is displaced from the interface with the substrate due to the presence of a transition region. The amount of the displacement depends on the slope of the concentration profile of the shallow dopant and the doping level of the deep dopant (Fe). The authors propose a method of determining the position of the  $\pi$ - $\nu$  junction based on measuring the capacitance of the electrolyte-semiconductor barrier with simultaneous chemical dissolution of a local region of the investigated structure. While this method does not enable measurement of the distribution of charge carrier concentration in the high-resistivity layer,

it does give a rather accurate indication of the position of the  $\pi$ - $\nu$  junction in compensated GaAs layers grown on a low-resistivity substrate. Figures 4, references 5 Russian.  
[129-6610]

UDC 621.315.592

PROPERTIES OF Ge-DOPED n-GaAs WHEN GROWING SINGLE CRYSTALS FROM MELT

Tomsk IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: FIZIKA in Russian Vol 26, No 11, Nov 83 (manuscript received 17 Jan 83) pp 94-98

KRIVOV, M.A., MALISOVA, Ye.V., MEL'CHENKO, E.N., MOROZOV, V.S., NIKIFOROVA, M.P., KHLUDKOV, S.S., GRIGOR'YEV, Yu.A., YEGOROVA, O.L. and OSVENSKIY, V.B., Siberian Physicotechnical Institute imeni V.D. Kuznetsov at Tomsk State University, State Scientific Research and Planning Institute of Rare Metals

[Abstract] The authors study the mobility, concentration, and majority carrier lifetime in the 80-500 K temperature range, and the spectra of photoconductivity and cathodoluminescence at 80 K in specimens of N-GaAs<Ge> with various electron concentrations and degrees of compensation (K). Four groups of specimens were studied with electron concentrations of  $N = 10^{16} \text{ cm}^{-3}$ ,  $K = 0.99$ ;  $n = 4 \cdot 10^{16} \text{ cm}^{-3}$ ,  $K = 0.97$ ;  $n = 10^{17} \text{ cm}^{-3}$ ,  $K = 0.86$ ;  $n = 10^{18} \text{ cm}^{-3}$ ,  $K = 0.67$ . The scattering mechanism is analyzed and the concentrations of donors and acceptors are determined. It was found that in addition to the simple point defects produced by donor and acceptor germanium atoms, complex defects are produced by interaction of the germanium dopant with lattice defects. The donors and acceptors have a decisive effect on electron mobility in homogeneous specimens, and are the principal scattering centers at temperatures of 90-300 K. The germanium acceptor centers may act as levels of attachment of minority carriers, and may determine the behavior of the temperature dependence of electron lifetime at temperatures of 160-300 K. The observed complex centers are radiative recombination centers. Figures 5, references 13: 5 Russian, 8 Western.  
[129-6610]

UDC 621.382.23.011.022:546.681'19

INFLUENCE THAT CONDITIONS OF GROWING EPITAXIAL GaAs LAYERS PRODUCED BY THE MOS-HYBRID METHOD HAVE ON PHOTOLUMINESCENCE SPECTRA

Tomsk IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: FIZIKA in Russian Vol 26, No 11, Nov 83 (manuscript received 17 Jan 83) pp 101-105

BABUSHKINA, T.S., ZEVEKE, T.A., MALKINA, I.G. and TOLOMASOV, V.A., Gorkiy Physicotechnical research Institute, Gorkiy State University imeni N.I. Lobachevskiy

[Abstract] An investigation is made of the influence that the temperature of growth and the composition of the vapor-gas mixture in the diffusion region have on photoluminescence spectra of GaAs films at 77 K. The shape of these

spectra confirms the hypothesis that capture of an uncontrolled impurity with level at a depth of  $0.026 \pm 0.003$  eV by the growing film is determined by the composition of the vapor-gas mixture, i.e. by the concentration ratio of arsine to trimethylgallium in the gas phase. In the temperature range of 560-670°C, this ratio is determined by the degree of arsine dissociation, and at a higher growth temperature by desorption of arsine from the surface. Figures 3, references 9: 7 Russian, 2 Western.  
[129-6610]

UDC 539.293:535.215

#### THERMOSTIMULATED CURRENTS IN ZnSe-GaAs HETEROSTRUCTURES

Tomsk IZVESTIYA VYSSHIKH UCHEBNIK ZAVEDENIY: FIZIKA in Russian Vol 26, No 11, Nov 83 (manuscript received 3 Jan 83) pp 110-111

VILISOV, G.T., GORBACHEVA, O.P., RAMAZANOV, P.Ye., SILIONOV, I.P., Siberian Physicotechnical Institute imeni V.D. Kuznetsov at Tomsk State University

[Abstract] Determination of the peculiarities of current transmission in the ZnSe-GaAs heterostructure (effects of switching and memory) necessitates data on the energy spectrum of traps in this structure. This paper is an attempt to determine their position by the method of thermostimulated currents. Measurements were done on heterostructures produced by epitaxial growth of ZnSe in the gas-transport technique on n-type and p-type GaAs. The ZnSe films were 2-3  $\mu\text{m}$  thick. Thermostimulated currents were measured from  $10^{-12}$  to  $10^{-6}$  A, with recording on a two-coordinate potentiometer. Thermoactivation processes leading to characteristic peaks on the thermostimulated current curves were observed for both polarities of the applied voltage. An intense peak showed up on all structures of n-p type ( $T_m \approx 240$  K) and n-n type ( $T_m \approx 210$  K) regardless of polarity or amplitude of the applied voltage. The energy position of the capture centers that give this maximum for anisotypic heterojunctions was found to be  $0.30 \pm 0.02$  eV. The concentration of these levels was about  $10^{17} \text{ cm}^{-3}$ . No attempt was made to separate the peaks forming the more complex maximum in structures of n-n type. Shallower trap levels were observed in heterojunctions of both types in the form of a blurred maximum on the curves of thermostimulated current at temperatures of 97-140 K. The activation energy of these traps was  $0.20 \pm 0.02$  eV, and concentration was about  $10^{16} \text{ cm}^{-3}$ . Analysis of the dark current temperature dependence of both types of structures also revealed a donor activation energy of 0.20 eV. The observed capture centers are assumed to be on the ZnSe side, and to be electron traps. It is shown that the 0.20 eV level can be attributed to a  $V_{\text{Se}}\text{-Ga}_{\text{Zn}}$  complex, while the 0.30 eV level may be associated with a  $V_{\text{Zn}}\text{-Ga}_{\text{I}}$  complex. It is pointed out that the complete energy spectrum of these structures is much more complicated, and depends on methods of producing the structures. Figure 1, references 5: 1 Russian, 4 Western.  
[129-6610]

## CIRCULAR POLARIZATION OF HOT PHOTOLUMINESCENCE, AND SPIN RELAXATION OF HOT ELECTRONS IN GALLIUM ARSENIDE CRYSTALS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 12, Dec 83 pp 2307-2310

ALEKSEYEV, M.A., KARLIK, I.Ya., MERKULOV, I.A., MIRLIN, D.N., NIKITIN, L.P. and SAPEGA, V.F., Physicotechnical Institute imeni A.F. Ioffe, USSR Academy of Sciences

[Abstract] Circular polarization of recombination luminescence of hot electrons is measured over a wide energy range in moderately doped p-GaAs crystals with acceptor concentration of the order of  $10^{17} \text{ cm}^{-3}$  or less. Excitation was by lines of  $\text{Kr}^+$  and He-Ne lasers on 1.65, 1.83, 1.92 and 1.96 eV, corresponding to electron energies of 0.11, 0.27, 0.34 and 0.38 eV. The specimens were held at a temperature of 10 K during measurement. The photoluminescence spectrum showed oscillations with period equal to the energy of long-wave LO phonons. For each excitation energy, measurements were made at the maximum of the first (high-frequency) peak in the spectrum. This corresponds to recombination luminescence of electrons not yet scattered (before emission of a phonon). It was found that the degree of circular polarization increases with decreasing electron energy in qualitative agreement with theory. The best quantitative agreement between theory and experiment is observed at a spin splitting constant equal to  $\alpha = 0.047$ , which is close to the value experimentally determined from spin relaxation of thermalized electrons in GaAs ( $\alpha = 0.06$ ). An analysis is made of the influence that the degree of circular polarization of an external magnetic field parallel to the direction of excitation has on polarization of hot photoluminescence. A maximum is observed on the curve for the degree of circular polarization as a function of magnetic field that is attributed to competition between two processes: 1. suppression of the depolarizing action of the effective magnetic field, and 2. elimination of the correlation between spin and quasimomentum due to cyclotron motion of electrons. For the limiting case where the precessional mechanism is suppressed and correlation is maximally disrupted, calculation in the spherical approximation yields a degree of circular polarization of 0.43, which is 0.05-0.07 greater than the experimental limit. Figures 3, references 9 Russian.

[141-6610]

## OPTICAL DETECTION OF EPR FROM PHOTOSTIMULATED CRYSTAL LUMINESCENCE

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 12, Dec 83 pp 2360-2363

ROMANOV, N.G., PETROV, V.A. and BARANOV, P.G., Physicotechnical Institute imeni A.F. Ioffe, USSR Academy of Sciences

[Abstract] This paper represents the first use of the method of optical detection of electron paramagnetic resonance to study photostimulated processes. The specimens were alkali halide crystals and crystals of fluorite type exposed

to x-radiation at 77 K. Such crystals contain autolocalized holes ( $V_k$  centers) and electron color centers that have absorption bands in the visible and near infrared. Photostimulated luminescence was excited by light in the absorption bands of the electron centers. The optically detected EPR spectra were recorded with respect to the intensity of photostimulated luminescence at 2 K in the 8-cm microwave band with modulation of the microwave field in the cavity at a frequency of 100-2000 Hz. In some cases the spectra were recorded with the microwave field at a constant level. The results show autolocalized excitons when F or F' centers are photostimulated in alkali halide crystals. Such complexes are formed when an autolocalized hole captures an electron. Photostimulation in the absorption bands of electron centers of irradiated fluorite crystals produces photostimulated luminescence in the ultraviolet. Observation of optically detected EPR spectra by photostimulated luminescence in crystals where the hole centers are autolocalized holes shows that the autolocalized exciton is formed as a result of capture of excited electrons by  $V_k$  centers. In fluorite crystals, the complexes are formed when the  $V_k$  centers produced by ionizing radiation capture electrons. Figures 2, references 8: 6 Russian, 2 Western. [141-6610]

#### PHOTOINDUCED EXTRACTION OF RADIATION FROM $Ti:LiNbO_3$ WAVEGUIDES WITH ROTATION OF POLARIZATION PLANE

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 23, 12 Dec 83 (manuscript received 30 Aug 83) pp 1409-1412

ZOLOTOV, Ye.M., KAZANSKIY, A.G., KAZANSKIY, P.G. and CHERNYKH, V.A.,  
Institute of General Physics, USSR Academy of Sciences, Moscow

[Abstract] The photorefractive effect shows up in  $Ti:LiNbO_3$  waveguides at powers of only 10-100  $\mu W$  on a wavelength of 0.63  $\mu m$ . This paper is a report on new photorefractive effects in planar diffuse waveguides: photoinduced extraction of radiation from a  $Ti:LiNbO_3$  waveguide with rotation of the polarization plane. The planar waveguides were prepared by diffusing titanium into Y-cut lithium niobate crystals from a layer 300  $\text{\AA}$  thick at 960°C for 6 hours. Light was coupled into the waveguide via a  $PbMoO_4$  prism and propagated along the x-axis. Two extraordinary H-modes and one ordinary E-mode were excited. As the extraordinary surface wave with power of 10  $\mu W$  propagated in the waveguide, radiation with ordinary polarization was observed to exit from the edge of the plate at an angle of 16° to the plane of the waveguide and with divergence corresponding to an extraction length of 15 mm, and extraction efficiency of about 0.1%. With an increase in power to 1 mW, the extraction length decreased to about 1 mm. Maximum extraction efficiency was 40%. Emission can be coupled into the waveguide analogously without external input devices, at the point where photoinduced extraction has occurred, the effect lasts for at least ten days. Scattering of the  $H_2$  mode by a photoinduced periodic structure is described. The cause of the photoinduced structure is not clear. A simple method is described for determining propagation losses for extraordinary surface waves. Figures 3, references 4: 2 Russian, 2 Western. [117-6610]

## OPTICAL LOW-DOSE EFFECT IN SOLID-STATE RADIATION PHYSICS

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 23,  
12 Dec 83 (manuscript received 9 Aug 83) pp 1448-1451

ATABEKYAN, R.R., VINETSKIY, V.L., GEVORKYAN, V.A., YEZOYAN, R.K. and  
YERITSYAN, G.N.

[Abstract] Recent research has demonstrated that low doses of irradiation by high-energy particles can improve the properties of some semiconductors, reducing resistance and increasing current carrier mobility. In this paper, the authors consider the possibility that such an effect might result in improvement in optical properties of crystals. Single crystals of unactivated corundum in the form of plane-parallel polished plates of 0.05-0.1 cm thick were exposed to a 50 MeV electron beam with intensity of 0.02  $\mu$ A. The cross section of the beam measured about 15 sq. cm. The minimum dose of irradiation was  $10^{10}$  el/cm<sup>2</sup>. Exposure was done at temperatures of 77 and 300 K. Absorption spectra were recorded at room temperature after each dose of irradiation. The results show that exposure with a dose of about  $10^{11}$  el/cm<sup>2</sup> reduces the absorption of corundum in the ultraviolet, which is an indication of improved transparency. This effect was independent of the temperature of irradiation, and of the method used for crystal growing, and was also observed at electron energies of 7.5 MeV. Figures 2, references 5: 3 Russian, 2 Western.

[177-6610]

## PASSAGE OF MAGNETOSTATIC SURFACE WAVES THROUGH PERIODIC SYSTEM OF PARALLEL METAL STRIPS

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 23,  
12 Dec 83 (manuscript received 17 May 83) pp 1459-1461

VASHKOVSKIY, A.V., VORONENKO, A.V., ZUBKOV, V.I. and KIL'DISHEV, V.N.,  
Institute of Radio Engineering and Electronics, USSR Academy of Sciences,  
Moscow

[Abstract] An experimental study is done on passage of a magnetostatic surface wave through a YIG film in the case where the path of propagation is blocked by a periodic structure of a row of 20 copper strips 2 mm long and 1.6  $\mu$ m thick. The period of the structure was varied from 40 to 120  $\mu$ m, and the width of the metal strips was varied from 2 to 14  $\mu$ m. The ration of the transmitted power to the incident power was measured as a function of frequency, and the amplitude-frequency response was determined as a function of the width of the strip, and the period of the structure. The results demonstrate the feasibility of constructing narrow-band microwave filters that use transmission of magnetostatic surface waves through a periodic structure of metal strips. Figure 1, references 4 Western.

[177-6610]



ROLE OF SURFACE IN CONDUCTIVITY AND PHOTOCONDUCTIVITY OF MAGNETIC  
SEMICONDUCTOR  $\text{CdCr}_2\text{Se}_4$

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 24,  
26 Dec 83 (manuscript received 27 Oct 83) pp 1473-1476

MOSHNYAGA, V.T., GOLANT, K.M. and VESELAGO, V.G., Institute of General  
Physics, USSR Academy of Sciences, Moscow

[Abstract] In connection with the discovery of strong surface absorption of light in single crystals of  $\text{CdCr}_2\text{Se}_4$ , the authors consider the influence that the surface of a specimen has on kinetic characteristics. The paper gives the results of electric and photoelectric measurements done on  $\text{CdCr}_2\text{Se}_4$  single crystals of p-n type after various stages of surface treatment: polishing, argon etching and chemical etching. All specimens were produced by spontaneous crystallization from solution in a melt. The results show that the surface of high-resistance specimens shunts their bulk electric and photoelectric properties. Removal of the surface layer by chemical etching leads to anomalies in the temperature dependence of conductivity that are typical of magnetic semiconductors, and also enables investigation of the influence that magnetic order has on processes of recombination of nonequilibrium current carriers. Figures 3, references 10: 5 Russian, 5 Western.  
[114-6610]

HIGH-EFFICIENCY PHOTODETECTOR FOR ULTRASONIC RADIATION

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 24,  
26 Dec 83 (manuscript received 31 Oct 83) pp 1516-1519

ALFEROV, Zh.I., GORELENOK, A.T., DANIL'CHENKO, V.G., KAMANIN, A.V., KOROL'KOV, V.I., MAMUTIN, V.V., TABAROV, T.S. and SHMIDT, N.M., Physicotechnical  
Institute imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] The paper gives the results of a study of intrinsic photoconductivity in thin epitaxial layers of p-InP grown from the liquid phase of substrates of semi-insulating  $\text{InP}<\text{Fe}>$  with resistivity of about  $10^7 \Omega \cdot \text{cm}$ . To reduce dark currents and get high sensitivity, epitaxial layers of  $n^0$ -InP lightly doped with rare-earth elements were grown in sapphire cassettes to a thickness of 5-10  $\mu\text{m}$ . A layer of heavily doped  $n^+$ -InP was grown over this layer, to which the ohmic contacts were applied, after which the  $n^+$  layer was etched away between contacts. Dark and illuminated current-voltage characteristics were determined, and also the gain as a function of voltage at different levels of illumination. The typical spectral characteristic of sensitivity of the photodetector at room temperature shows a considerable increase in quantum yield in the short-wave region. Sensitivity does not drop sharply in the short-wave region beyond the absorption edge, which is attributed to the low surface recombination rate in InP. For this reason, the absolute sensitivity on a wavelength of



300 nm is at least 40 A/W with application of a voltage of 40 V. When photoconductivity was excited by triangular light pulses with wavelength of 337 nm and rise time of 10 ns, the shape of the laser pulse was repeated without distortions for a range of applied voltages from 0.2 to 100 V. Figures 2, references 6: 4 Russian, 2 Western.  
[114-6610]

#### EFFECT OF LIGHT FIELD ON ANISOTROPY OF REFRACTIVE INDEX OF CdS CRYSTAL

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 24, 26 Dec 83 (manuscript received 9 Oct 83) pp 1527-1530

VIDMONT, N.A., MAKSIMOV, A.A., TARTAKOVSKIY, I.I. and EDEL' SHTEYN, V.M.,  
Institute of Solid State Physics, USSR Academy of Sciences

[Abstract] Until now, all semiconductors showing the effect of optical bistability have had cubic structure. In this paper, the authors study a uniaxial crystal of CdS for optical bistability. The specimen was placed in an optical helium cryostat at 4.5 K between crossed polaroids. The angle between the  $\vec{c}$  axis of the crystal and the plane of polarization of the Nicol prism was about 45°. To increase sensitivity, transmission was studied in the region near exciton resonance. The intensity of incident radiation was varied by filters. The transmitted light was analyzed by a DFS-24 spectrometer. It was found that increased intensity of the incident light gives rise to a shift in the transmission spectrum into the short-wave region, indicating a reduction in anisotropy of the refractive index. In particular, this shift means that on the wavelength initially corresponding to minimum transmission, an increase in the intensity of the incident light makes the system more transparent, while transparency decreases on a shorter wavelength. Due to this behavior, a light pulse can be used to tailor a second pulse. If a low-intensity test pulse with broad spectrum is applied simultaneously with the pulse from a tunable dye laser, the output pulse may be broadened or narrowed, depending on observation wavelength. The mechanism responsible for the observed shift in anisotropy of the refractive index is attributed to formation of an electron-hole plasma. Figures 2, references 4 Western.  
[114-6610]

UDC 535:548.0

#### CLASSES OF CRYSTALS WITH SQUARE-LAW AND CUBIC NONLINEARITY THAT PERMIT QUASISYNCHRONOUS OPTICAL WAVE INTERACTION

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 21 Jan 82) pp 86-90

YUSUPOV, D.B.

[Abstract] The author considers nonlinear-optics crystals that do not meet the usual conditions for synchronism of interacting light waves, but that may be used in a quasisynchronous interaction arrangement to produce

cumulative nonlinear optical effects with concomitant large conversion factors. The nonlinear medium consists of layers with inverted optical axes, the thickness of an individual layer being determined from the condition of a change in phase ratio by  $\pi$  due to phase detuning. An analysis is made of the process of generation of the N-th harmonic in a laminar medium in the predetermined field approximation. Symmetry classes are studied for uniaxial crystals that permit quasisynchronous interactions on square-law and cubic susceptibility. An examination is made of versions of layer orientation for different types of interaction in which the effective nonlinear susceptibilities change sign. It is found that quasisynchronous interactions can be realized in a wide range of crystals with both types of nonlinearity. The possibility of quasisynchronous interaction of light waves means that crystals with the greatest nonlinearity need not be excluded from nonlinear-optics applications due to absence of synchronism for the mode of interaction associated with this nonlinearity. Figure 1, tables 4, references 8: 2 Russian, 6 Western.

[145-6610]

## ELECTRICITY AND MAGNETISM

### USING RELATIVISTIC ELECTRON BEAMS TO GENERATE MICROWAVE PULSES OF MICROSECOND DURATION

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 23, 12 Dec 83 (manuscript received 20 Aug 83) pp 1435-1438

BURTSEV, V.A., ZAYTSEV, N.I., KOVALEV, N.F., KULAGIN, I.S., NIKONOV, A.G., POTELIN, M.I., ROYFE, I.M., SAVEL'YEV, Yu.M. and ENGEL'KO, V.I.

[Abstract] The paper gives the results of experiments on generation of microwave radiation using a facility with multipoint explosive emission cathode as the source of electrons. The electrode had a conical working surface with area of  $1.5 \cdot 10^3 \text{ cm}^2$ . Bundles of graphite fibers served as the cathode points. Beam diameter could be varied by changing magnetic field geometry and cathode configuration. Square pulses of high voltage were generated by the Marx method. The amplitude of the accelerating pulse was 300 kV with duration of 25  $\mu\text{s}$ . The microwave pulses were produced in a self-excited oscillator arrangement. Output pulse duration was 8  $\mu\text{s}$  for a voltage of 160 kV across the electron gun, and 3  $\mu\text{s}$  for gun voltage of 240 kV. These modes correspond to emission power levels of 10 and 15 MW respectively. Emission wavelength was 8.6 cm for gun voltage of 160 kV, which is close to the theoretical prediction, and the spectral width of the stimulated radiation did not exceed 1.5%. Figures 2, references 6 Russian.  
[117-6610]

### SPATIAL COHERENCE OF EMISSION SOURCE WITH RADIATION PATTERN $\cos^m \theta$ IN LONGITUDINALLY INHOMOGENEOUS MEDIA WITH SQUARE-LAW REFRACTIVE INDEX PROFILE

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 24, 26 Dec (manuscript received 26 Jun 83) pp 1489-1494

KRIVOSHLYKOV, S.G., PETROV, N.I. and SISAKYAN, I.N., Physics Institute imeni P.N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] The authors study the evolution of the transverse spatial correlation function of a source with radiation pattern  $I(\theta) \sim \cos^m \theta$  ( $0 < \theta < \pi/2$ ,  $m \geq 1$ ) in longitudinally inhomogeneous media with square-law profile of the index of refraction. It is shown that the correlation radius increases with increasing  $m$ . When  $m = 2$ , the expression derived for the

degree of spatial coherence is analogous to that for excitation of a waveguide by a spatially incoherent source. Analysis of the behavior of the function for the correlation radius shows that it is completely determined by parameters of longitudinal inhomogeneity, and is independent of the curvature of the axis. Therefore, the influence that different regular longitudinal inhomogeneities have on the coherence properties of the field on a longitudinally homogenous section beyond a barrier can be studied by simply changing the values of parameters. Figures 2, references 10: 8 Russian, 2 Western.

[114-6610]

#### INVESTIGATION OF BRAGG REFLECTION OF ELECTROMAGNETIC SURFACE WAVES BY DIFFRACTION GRATING

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 24, 26 Dec 83 (manuscript received 21 Aug 83) pp 1502-1506

BOLTAR', K.O., ZHIZHIN, G.N., SIGAREV, A.A., SURIS, R.A. and FEDIRKO, V.A.

[Abstract] Wide-band spectra of conversion of electromagnetic surface waves by diffraction gratings on a metal surface usually show a number of abrupt dips due to Bragg surface wave reflection by the periodic structure of the gratings. In this paper, the authors study the way that the shape and width of a dip in the spectrum of a grating converter of surface electromagnetic waves depend on the grating parameters and conditions of excitation. The spectrum of an electromagnetic surface wave propagating over an inhomogeneous metal surface can be obtained by diagonalizing the inverse propagator of the wave equation  $G^{-1} = G_0^{-1} - V$ , where  $G_0$  is the propagator for the smooth metal surface, and  $V$  is the effective potential that describes the influence of surface inhomogeneities. Taking  $V$  is a small parameter, perturbation theory is used in the two-wave approximation with consideration of only the interaction of the electromagnetic surface wave with opposite directions of the wave vector. The expressions derived for the shape and width of dips in the spectrum are confirmed by experimental data. Figures 2, references 7 Russian.

[114-6610]

#### GENERATION OF INTENSE MICROWAVE EMISSION BY HIGH-CURRENT MICROSECOND BEAM IN TRIODE SYSTEM

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 24, 26 Dec 83 (manuscript received 17 Jun 83) pp 1510-1513

DIDENKO, A.N., ZHERLITSYN, A.G., SULAKSHIN, A.S., FOMENKO, G.P., TSVETKOV, V.I. and SHTEYN, Yu.G.

[Abstract] In relativistic microwave devices now being developed, pulse duration is much shorter than the current pulse of an intense electron beam because of microwave breakdown in the beam-generated plasma. In this paper,

the authors do experiments to study generation of microwave emission in a triode system on intense beams of microwave duration, to determine the microwave pulse duration, and to ascertain the restrictions on duration. The experiments were done on the "Tonus-2M" high-current accelerator. In addition to voltage, beam current, and microwave radiation, bremsstrahlung was registered by an ELU-19 electron multiplier sensitive to bremsstrahlung with energy in excess of 100 keV. The instant when the plasma covered the cathode-anode gap was estimated from the bremsstrahlung pulse. A positive high-pressure pulse was applied to the anode in the form of a grid of fine steel wires. Electrons emitted from the cathode were accelerated in the cathode-anode gap, and after passing through the anode they formed a virtual cathode at a distance about equal to the cathode-anode spacing. Oscillation of the electron beam in the resultant potential well gives rise to intense electromagnetic radiation. Measurement of the parameters of the microwave pulse showed that duration is limited by the time that the plasma covers the anode-cathode gap. The efficiency of conversion of energy of the electron flux to microwave radiation energy reaches 40% or more. The triode system can produce high-energy microwave emission in the centimeter band at comparatively low beam currents (5-10 kA), accelerating voltages (500-600 kV) and moderate pulse durations (1-2  $\mu$ s). Figures 2, references 5: 4 Russian, 1 Western.  
[114-6610]

UDC: 531.391+532.526+532.592

STABILITY OF STATIONARY ROTATION OF CYLINDER FILLED WITH STRATIFIED VISCOUS INCOMPRESSIBLE FLUID

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 5, Oct 83  
(manuscript received 3 Feb 83) pp 1073-1076

DERENDYAYEV, N.V.

[Abstract] A method is proposed for solving the plane problem of small-scale stability of steady rotation of a cylinder completely filled with a stratified viscous incompressible fluid. The angular velocity of rotation of the cylinder is assumed to be held constant, and its axis is secured in an axisymmetrical viscous elastic mount. An example of the solution of the stability problem using the proposed method is given. It is established that resonant excitation of internal waves within the rotating fluid filling the cylinder is an important factor underlying the occurrence of instability. An example is given of the investigation of the stability of steady rotation of a cylinder completely filled with a stratified viscous incompressible fluid whose distribution density in steady-state rotation is  $\rho_0(r) = \rho_{00} \exp(\alpha r^2)$ , and whose viscosity distribution  $\mu_0(r)$  has a characteristic spatial scale no smaller in order of magnitude than the radius of the cylinder. References 6: 4 Russian, 2 Western.  
[118-6900]

UDC: 532.517.4

FORMATION OF COHERENT STRUCTURES BY ACOUSTICAL EFFECTS IN A TURBULENT WAKE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 1, 1984  
(manuscript received 20 Jun 83) pp 50-53

YANENKO, N.N., academician, BARDAKHANOV, S.P. and KOZLOV, V.V., Institute of Theoretical and Applied Mechanics, Siberian Division, USSR Academy of Sciences, Novosibirsk

[Abstract] A study is made of the transformation of acoustical disturbances to vortex disturbances, i.e., coherent structures, in a turbulent wake beyond a thin plate with a sharp trailing edge. Experiments were performed in

a subsonic wind tunnel at the author's institute with a cross section of  $0.2 \times 0.2$  m at a flow speed  $U_{\infty}=10$  m/s. The wake was formed downstream from a 300 mm plate with sharp leading and trailing edges and maximum thickness of 3 mm. A special turbulizer was used. Acoustical disturbances were produced by an audio oscillator and loudspeaker installed in the wall of the wind tunnel. Mean flow parameters and pulsation characteristics were recorded and processed by a "DISA" heat-loss anemometer and FAT-1 frequency analyzer. It was shown that the audio oscillations are intensively converted to vortex disturbances in the turbulent wake downstream from the plate and occur in laminar flows. Figures 4, references 4: 2 Russian, 2 Western.  
[25-6508]

UDC 532.517

#### TRANSITION FROM LAMINAR TO TURBULENT FLOW UNDER ACTION OF ACOUSTIC VIBRATIONS

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 45, No 4, Oct 83  
(manuscript received 30 Nov 81) pp 560-563

SHEL'PYAKOV, A.N., KASIMOV, A.M. and ISUPOV, G.P., Izhevsk Institute of Mechanics, Votkinsk evening branch

[Abstract] An experimental study was made of transition from laminar to turbulent flow, with formation of two conical jets, under the action of acoustic vibrations. The experiment was performed with air discharge through a capillary nozzle, using a smoke generator for visualization, a sound generator for acoustic action, a piezoelectric crystal for measurements, and a camera for recording the flow pattern. A laminar jet was found to be most sensitive to acoustic vibrations at a frequency of 9 kHz and, therefore, the sound generator was operated at that frequency. Slight frequency deviations were found to change the positions of both cones relative to the sound generator. The effect of smoke particles and air preheating on the test results was determined by separately aiming the jet at a water surface and recording the velocity distribution in this configuration. The study has revealed the existence of diverse acoustic segments in a laminar stream and a substantial difference between laminar-to-turbulent transitions with or without acoustic action respectively. Figures 3, references 3 Russian.  
[93-2415]

## PROPAGATION OF GAS JET IN LIQUID

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 45, No 4, Oct 83  
(manuscript received 5 May 82) pp 542-554

SURIN, V.A., YEVCHENKO, V.N. and RUBIN, V.M., Dnepropetrovsk Institute of Mechanics

[Abstract] A comprehensive experimental study was made of discharge of a gas jet from an orifice and its evolution in a liquid medium. Nitrogen, air, helium, chlorine, carbon dioxide, hydrogen chloride, ammonia, and water vapor superheated to 200-250°C were discharged vertically up, vertically down, or laterally into water at 18-100°C as well as into aqueous solutions of KOH and NaOH, under pressures varied from hydrostatic to  $41 \cdot 10^5$  Pa. They were discharged through sonic ( $M = 0.005-1.0$ ) cylindrical, conical nozzles and supersonic ( $1.0 < M \leq 3.0$ ) deLaval, axisymmetric, flat nozzles with orifices 2-50 mm wide. The discharge velocity varied from 2 to 1000 m/s and the jet underexpansion ratio varied from 1 to 20. The study has yielded data on the mechanisms of gas-liquid interaction, structure and dynamics of the interaction space, and dependence of those on the discharge conditions and on the degree of gas assimilation. Experiments were performed in both continuous and pulse modes, the latter for a study of transients and back shocks. Figures 4, references 28: 26 Russian, 2 Western.  
[93-2415]

UDC 517.958:532.5

## FREE OSCILLATIONS OF IDEAL STRATIFIED FLUID IN CONTAINER

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 24, No 1, Jan 84 (manuscript received 12 Mar 82) pp 109-123

KOPACHEVSKIY, N.D., Simferopol, and TEMNOV, A.N., Moscow

[Abstract] Oscillations of an ideal incompressible fluid with a density which at standstill varies in the vertical direction are analyzed, assuming that the fluid container of arbitrary shape has finite dimensions and is stationary. The problem is formulated for such a fluid completely filling a closed container with an initially stable stratification and for small movements under forces of gravity and buoyancy occurring within its volume. The corresponding equations for the velocity field, deviation of the pressure field from the static one at equilibrium, and deviation of the density field from the initial one are linearized in the Boussinesq approximation. A solenoidal displacement field is then introduced and the equation for the density field kinetics is integrated with respect to time. The resulting initial-value boundary-value problem is put in the form of an operator equation, upon introduction of both inherent and necessary Hilbert spaces. This equation is solved on the basis of two theorems with a lemma each pertaining respectively



to the pressure field, which depends only on the field of vertical displacements, and to the condition for existence of a unique solution to the stratification evolution problem. The oscillation spectrum at constant buoying frequency is analyzed next, including natural oscillations found from the corresponding eigenvalue problem, specifically for the case of exponential stratification in a cylindrical container. The spectral density of oscillations here is calculated from the solution to the corresponding Neumann problem, with the aid of three other theorems and for lemmas. In the more general case of arbitrary vertical stratification this problem is solved by separation of variables and the properties of the spectrum are determined with the aid of another lemma and two additional theorems. The authors thank V.A. Marchenko for attention, assistance and helpful suggestions. References 12 Russian.

[94-2415]

UDC 517.9:533.7

#### COMPLETELY CONSERVATIVE CORRECTION OF FLUXES IN PROBLEMS OF GAS DYNAMICS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 3, Jan 84  
(manuscript received 27 May 83) pp 524-528

GOLOVIZNIN, V.M., RYAZANOV, M.A., Academician SAMARSKIY, A.A. and  
SOROKOVNIKOVA, O.S., Moscow State University imeni M.V. Lomonosov

[Abstract] An algorithm of completely conservative correction is constructed for numerical solution, in mixed Euler-Lagrange variables, of problems of gas dynamics where expressions for convective fluxes of mass, momentum, and energy have been approximated and where violation of the entropy balance can lead to erroneous results. This algorithm is demonstrated on a simple one-dimensional system of equations for an object with plane symmetry. A uniform finite-difference scheme is used for fluxes of momentum, kinetic energy, mass, and internal energy, a scheme selected arbitrarily as the optimum one with balanced approximations in time and in space. Weighting combines the advantages of first-order and second-order approximation, the weight factors being determined according to a special variant of the "predictor-corrector" method. This explicit completely conservative algorithm was compared for accuracy with other algorithms (Godunov, Zhmakin-Fursenko, Boris-Book SHASTX) on test problems in Euler variables. Unlike the others, it was found to simulate a relatively weak rarefaction wave with monotonically spreading front exactly. References 14: 10 Russian, 4 Western.

[110-2415]

## SIMILARITY CRITERIA FOR SPECTRA OF PRESSURE FLUCTUATIONS IN TURBULENT BOUNDARY LAYER AT WALL

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 29 Nov 82) pp 58-61

YEFIMTSOV, B.M.

[Abstract] Spectra of pressure fluctuations in turbulent boundary layers at a wall are analyzed, for the purpose of generalization on the basis of three dimensionless criteria: Mach number, Reynolds number and Strouhal number. Semiempirical relations are established for the dimensionless spectral density of such fluctuations as function of those three numbers, low and high ranges of each of these numbers being characterized by different trends of that spectral density function. The relations are based on experimental data covering a wide range ( $M=0.015-4$ ,  $Re=6\cdot 10^2-1.5\cdot 10^5$ ,  $St=0.2-10^4$ ) of zero-gradient flow of air past aircraft wings and through wind tunnels, those data having been analyzed statistically according to the theory of random processes and the theory of similarity. Dependence of the spectral density on the Mach number is manifested by changes in the average local frictional stresses at the wall as well as in the density and the kinematic viscosity of air. Transition from a spectral density independent of  $St$  to one inversely proportional to the two-thirds power or the ten-thirds power of  $St$  occurs within the  $St \sim 200-300$  range and depends on whether  $St \ll 1.3Re^{7/8}$  or  $St = 1.3Re^{7/8}$  respectively. Transition from a spectral density independent of  $Re$  to one proportional to the one-seventh power of  $Re$  (while remaining independent of  $St$ ) occurs within the  $Re \sim 2000-3000$  range. Into account is taken the relative thickness of the boundary layer, which determines the magnitude of pressure fluctuations under any conditions of flow. Figures 5, references 6: 4 Russian, 2 Western.  
[90-2415]

UDC 534.222

## FRONT STRUCTURE OF WEAK SHOCK WAVE IN RELAXING MEDIUM

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 6, Nov-Dec 82  
(manuscript received 22 Oct 81) pp 731-736

BOZHKOVA, A.I. and KOLOMENSKIY, A.I., Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences

[Abstract] Propagation of sound waves with finite amplitude through a fluid medium where two relaxation processes occur is analyzed, this case being an extension of the case of only one relaxation process and the results being further extendable to arbitrarily many relaxation times in a fluid. The pressure is assumed to be a function of density, entropy, and two internal parameters of the medium. On this basis, the corresponding equations of hydrodynamics are supplemented with two equations of relaxation and an

equation of state. Disregarding terms of higher than second order smallness and assuming negligible changes in entropy, a nonlinear differential equation is obtained which describes the transition from sound wave to weak shock wave and then the structure of the wave front in terms of the velocity profile. The analysis continues for a low acoustic Mach number in a medium where the relaxation times of the two processes are  $\tau_1 \gg \tau_2 \gg b/\rho c^2 m_1$  ( $b$ - dissipation coefficient,  $\rho$ - density,  $c$ - speed of sound) with the relative heights  $m_1$  and  $m_2$  of dispersion steps of the same order of magnitude. The steady-state wavefront is calculated in a system of coordinates fixed to it. The results are applicable to excitation of sound pulses by means of electric breakdown or with a laser beam, through optical breakdown, surface evaporation, or the thermal mechanism. The authors thank F.V. Bunkin for discussion of the results. References 9 Russian.  
[92-2415]

UDC 534.204.1

# EVALUATING EFFECT OF FLOW ON PRESSURE FIELD OF MONOCHROMATIC POINT SOURCE IN HOMOGENEOUS OCEAN

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 28, No 6, Nov-Dec 82  
(manuscript received 23 Jun 81) pp 758-762

GOLOD, O.S. and GRIGOR'YEVA, N.S., Northwestern Polytechnic Correspondence Institute

[Abstract] A homogeneous ocean of uniform depth from free surface to solid bed is considered, assuming a refractive index  $n(z) = c_0 c^{-1}(z) \approx 1$  in it. The propagation characteristics of sound waves from an immersed monochromatic point source are evaluated first for the nonflow case and then for the case of laminar horizontal flow, with corresponding boundary conditions for the pressure and the pressure gradient. The effect of flow on the pressure field is determined with the aid of the partial differential eikonal equation, after the latter has been transformed into the characteristic system of ordinary differential equations and those have been integrated to yield the ray trajectories. With correction for optical wavelengths, the calculations have been programmed on a BESM-6 high-speed computer. Typical results are shown for an ocean depth of 2000 m and an acoustic velocity  $c_0 = 1500$  m/s in it. The velocity profile in the subsurface layer was assumed to be bilinear. The authors thank M.A. Kovalevskiy for assisting with calculations. Figure 1, table 1, references 10: 5 Russian, 5 Western.  
[92-2415]

## NONCONTRADICTORY METHOD OF CALCULATING RADIATION TRANSFER, AND PROBLEM OF SHOCK WAVE STRUCTURE

Novosibirsk ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI in Russian  
Vol 142, No 6, Nov-Dec 83 (manuscript received 21 Oct 82) pp 42-47

VYSKREBENTSEV, A.I., NUZHNYI, V.A. and RAYZER, Yu.P., Moscow

[Abstract] Detailed numerical calculations of equations of radiation transport and gas dynamics for a steady shock wave in air done by Zinn and Anderson [PHYSICS OF FLUIDS, Vol 16, No 10, 1973] have shown that for waves with amplitude near the critical point the iteration process does not converge to a final solution. This would seem to indicate that supercritical steady-state shock waves cannot exist. In this paper the authors analyze the problem of shock wave structure with consideration of radiant heat exchange in the one-dimensional steady state in a coordinate system fixed to the wavefront. The iteration procedure used in solving the problem eliminated the possibility of contradiction by matching the computational procedure with the factors that do not allow the temperature at any point in front of the shock to rise above the temperature behind the wavefront. The procedure yields temperature distributions in complete qualitative agreement with predictions of analytical theory, unambiguously demonstrating the fundamental possibility of existence of supercritical waves. Figures 5, references 11: 10 Russian, 1 Western.  
[134-6610]

UDC 536.46;621.45.022

## GASDYNAMIC STUDY OF MODEL WITH COMBUSTION IN SHOCK TUNNEL

Novosibirsk ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI in Russian  
Vol 142, No 6, Nov-Dec 83 (manuscript received 11 Oct 82) pp 58-66

BAYEV, V.K., SHUMSKIY, V.V. and YAROSLAVTSEV, M.I., Novosibirsk

[Abstract] The experimental difficulties involved in studies of supersonic or hypersonic airflows on facilities with combustion processes have led to the idea of using high-enthalpy facilities with short test time. However, the earliest attempts at using shock tubes for this purpose were not completely successful because times of the order of 3 ms are simply inadequate for studying the working process and force characteristics. Shock tunnels can provide a working time from a few hundredths to several tenths of a second, and initial research has shown that they should be completely suitable for testing models with combustion in a high-enthalpy airflow. This paper gives the results of such studies in the IT-301 shock tunnel on a gasdynamic model with hydrogen combustion. The purpose of the research was to determine the force characteristics of the model, compare theoretical and experimental data, evaluate weight measurements of

completeness of hydrogen combustion inside the model, and determine the effect that operation of the internal duct has on operation of the airscoop of the model. Figures 5, references 19: 18 Russian, 1 Western.  
[134-6610]

UDC 533.6.011.55.011.6:629.7.025.1

#### HYPERSONIC THREE-DIMENSIONAL FLOW OF RADIATING GAS AROUND WING

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian  
Vol 142, No 6, Nov-Dec 83 (manuscript received 3 Sep 82) pp 71-78

GOLUBINSKIY, A.I. and GOLUBKIN, V.N., Moscow

[Abstract] When a vehicle enters the upper layers of the atmosphere at velocities near escape velocity, radiation may have an appreciable effect on the flow of gas around the vehicle, and radiative heat losses may be comparable with convective losses, or even greater. Theoretical studies of hypersonic flow of radiating gas around solids have been mainly numerical. The initial approximation of the thin shock layer method has been used to analyze hypersonic flow around a wedge and a cone with consideration of radiation (planar and axisymmetric flows respectively). In addition, it is important to study the features of flow of radiating gas around three-dimensional bodies. In this paper the authors consider three-dimensional hypersonic flow around a wing at a finite angle of attack with consideration of radiation at high temperature. It is assumed that the compressed gas layer adjacent to the windward surface of the wing is optically transparent, i.e. the mean free path of radiation is much greater than the characteristic thickness of the compressed layer. Absorption of radiation in the gas is disregarded, which is justified for flight altitudes that are not too high. The state of the gas is taken as equilibrium before and after the head shock wave. The thin shock layer method is used to find a general solution of equations of gas dynamics expressing all flow parameters in terms of the shape of the head shock wave. The problem of determining waveshape is formulated, and a class of exact solutions is obtained. An investigation is made of the influence that radiation has on thickness of the shock layer, temperature, and pressure distribution. The distribution of radiative heat flux toward the wing is calculated. Figures 6, references 11: 10 Russian, 1 Western.  
[134-6610]

UDC 532.517.4; 532.525.2

#### MEASUREMENT OF CONDITIONALLY AVERAGED TURBULENCE CHARACTERISTICS IN PLANE WAKE BEHIND CYLINDER

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian  
Vol 142, No 6, Nov-Dec 83 (manuscript received 30 Sep 82) pp 87-94

PRASKOVSKIY, A.A., Moscow

[Abstract] Methods are currently being actively developed for describing turbulent flows based on equations for probability density functions of

pulsations in velocity and concentration. In closure of the equations for probability density functions, certain hypotheses of a physical nature are used that require experimental verification. In particular, in closure of the equation for probability density functions of flow velocity pulsations based on Kolmogorov-Obukhov theory, it has been hypothesized that in a turbulent liquid the dissipation of turbulence energy measured at a fixed velocity is independent of this velocity. This hypothesis has been verified by measurements of variance of the derivative of the flow velocity component in the plane of symmetry of the wake behind a circular cylinder where flow is completely turbulent. In this paper, the author verifies the same hypothesis in regions of turbulent flow where the coefficient of intermittence differs from unity, the turbulence energy being evaluated from the results of measurements of the variance of the time derivative of the longitudinal velocity component. The measurements yield some other conditionally averaged characteristics of flow turbulence that are of independent interest. Figures 6, references 14: 9 Russian, 5 Western.  
[134-6610]

UDC 532.526.011.56

# HYPERSONIC FLOW OF VISCOUS GAS ON SURFACE OF BLUNT CONE WITH STRONG BLOW-IN IN BLUNTED REGION

Novosibirsk ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI in Russian  
Vol 142, No 6, Nov-Dec 83 (manuscript received 13 Oct 82) pp 94-101

YERMAK, Yu.N., Moscow

[Abstract] An investigation is made of the problem of gas absorption by the lateral surface of a cone when the gas is blown into the region of slight bluntness of the cone. It is assumed that the cone is located in a laminar hypersonic flow of viscous gas. In the vicinity of the bluntness, the gas is blown in so that the boundary layer is displaced from the surface and becomes a mixing layer with thickness much less than that of the blown-in gas. The thickness of the blow-in layer in turn is much less than the thickness of the shock layer, and the thickness in this layer is described by equations of an inviscid boundary layer. The blow-in layer remains inviscid at some distance downstream and on the lateral surface of the cone, where blow-in stops. However, beyond this point the gas layer is absorbed by the boundary layer on the surface of the body and by the mixing layer on the contact boundary with the hot gas behind the shock wave. Figures 3, references 6 Russian.  
[134-6610]

## UNSTEADY MOTION OF CIRCULAR CYLINDER IN TWO-LAYER FLUID

Novosibirsk ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI in Russian  
Vol 142, No 6, Nov-Dec 83 (manuscript received 9 Jul 82) pp 101-106

BUKREYEV, V.I., GUSEV, A.V. and STUROVA, I.V., Novosibirsk

[Abstract] The plane problem of wave currents that arise when a dipole with time-variable moment moves in the upper layer of a two-layer fluid is considered in the linear approximation. It is assumed that this is equivalent to motion of a circular cylinder of given radius at given velocity. The fluid is taken as inviscid, incompressible, with two layers of different density. The y-axis is taken vertically upward, and the horizontal x-axis coincides with the unperturbed interface. It is assumed that at time  $t = 0$ , a dipole with variable moment  $m(t)$  begins to act in the upper fluid layer at point  $x = 0$ ,  $y = h$  so that the trajectory of its motion takes the form  $x = c(t)$ ,  $y = h$ . Flow is assumed to be potential in each layer. The theoretical analysis is verified by experiments on generation of internal waves in a two-layer liquid: water + kerosene. The law of unsteady motion of the cylinder was monitored by rheostate sensors. The experiments confirm the theory when effects of viscosity on wave damping and initial perturbation are taken into consideration. Figures 3, references 4: 3 Russian, 1 Western. [134-6610]

UDC 532.516

## LONGITUDINALLY ORIENTED CELLULAR STRUCTURES OF TAYLOR-GERTLER VORTEX TYPE ON HIGH-PRESSURE SIDE OF ROTATING CHANNELS

Novosibirsk ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI in Russian  
Vol 142, No 6, Nov-Dec 83 (manuscript received 13 Oct 82) pp 129-134

KUZ'MINSKIY, A.V., SMIRNOV, Ye.M. and YURKIN, S.V., Leningrad

[Abstract] Analysis in the linear approximation of the stability of Poiseuille flow between two plates rotating about the axis parallel to the plates and normal to the direction of the main flow shows that the flow is least stable for perturbations in the form of standing waves known as Taylor-Gertler vortices. While experimental data agree satisfactorily with the linear theory, there remains the problem of the influence that lateral bounding walls have on the stability of the main flow in channels of square cross section. The formulation of this important problem is described, and experimental results are given. The decisive parameters for a channel with given ratio of sides  $\kappa = h/\ell$  are taken as the Reynolds number  $Re = w_m \ell / \nu$  and the parameter of rotation  $K = \omega \ell / w_m$ , where  $h, \ell$  are the lengths of the sides of the cross section, the side of length  $h$  being parallel to the axis of rotation, and  $w_m$  is the average flowrate. Experiments were done in plexiglas channels with water as the working fluid. The hydrogen bubble method was used, with a tungsten filament as the cathode and a stainless

steel plate as the anode. Pulses with amplitude of 25-100 V, duration of 0.2-50 ms and recurrence rate of 0.5-10 Hz through the filament generated bursts of marker bubbles. Recording was by a camera rotating with the apparatus. It was found that the limit of stability of the main flow increases with decreasing  $\kappa$ , which is attributed to a reduction in the characteristic transverse dimension of the region of flow where rotation has a destabilizing effect. Figures 4, references 10: 5 Russian, 5 Western. [134-6610]

UDC 532.526

#### SEPARATIVE LAYER IN HIGH-TEMPERATURE FLOWS

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNIЧЕСКОY FIZIKI in Russian Vol 142, No 6, Nov-Dec 83 (manuscript received 26 Oct 82) pp 138-146

BOBNEV, A.A., Novosibirsk

[Abstract] The author considers the problem of discharge of a high-temperature jet from a cylindrical orifice in the formalism of boundary layer theory. An asymptotic expansion is constructed for solutions of the problem on the thin layer that separates the high-temperature region of flow of compressible gas from the region of flow of cool incompressible gas. Arguments are presented to support the thesis that this separative layer belongs to a new class of phenomena. Figures 5, references 4 Russian. [134-6610]

UDC 532.542:532.501.132

#### UNSTEADY SWIRLING FLOW IN CYLINDRICAL CHANNEL

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 46, No 1, Jan 84 (manuscript received 10 Oct 82) pp 21-24

FAFURIN, A.V. and PUSTOVOYT, Yu.A., Kazan Institute of Chemical Technology imeni S.M. Kirov

[Abstract] The paper gives the results of an experimental study of the evolution of tangential wall stresses and local angles of twisting with translational-rotational motion of fluid in a pipe with unsteady flow of working fluid. Streams were swirled with different intensities at the pipe inlet by three guide vane assemblies with trailing edge angles of 30, 45 and 60°. A special pulsator installed at the end of the working section was used to create unsteady flow. Tangential wall stresses were measured by a "projecting tube" method. The instantaneous values of the local angles of swirl were measured from the deflection of silk threads fastened on the inside surface of the channel in control cross sections. The deflections of the thread were recorded by a high-speed motion picture camera synchronized with an oscilloscope. The resultant data show that the presence of a



tangential component of motion has a considerable effect on the nature of variation in the parameters of the unsteady flow. In the accelerated part of the period of the oscillations, the unsteadiness suppresses effects caused by swirling of the flow, while it enhances such effects in the decelerated part of the flow. In steady translational-rotational flow, the angle of swirl is independent of the Reynolds number, being completely determined by the intensity of the initial twist. Acceleration of the flow reduces the local angle, while deceleration increases it. Figures 2, references 5 Russian. [137-6610]

UDC 532.517.4

#### THEORETICAL STUDY OF FLOW AROUND SINGLE AND DOUBLE STEPS IN TWO-DIMENSIONAL CHANNEL

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 46, No 1, Jan 84  
(manuscript received 12 Aug 82) pp 24-30

MAYOROVA, A.I.

[Abstract] The paper gives the results of theoretical analysis of turbulent flow of an incompressible fluid in a planar channel with abrupt widening in the form of one and two steps. The calculations are based on a two-parameter turbulence model, the steps are assumed to be symmetric relative to the middle plane, and degrees of expansion are taken in a range of 1.3-4.0. Coefficients of pressure recovery and hydraulic losses are determined. It is shown that the Carnot-Borda formula is applicable to a channel with a single step at degrees of expansion of 2-2.5. It is found that flow symmetry is disrupted for a channel with a double step when the degree of expansion exceeds 1.5, which has been confirmed by experimental data. The coefficient of recovery of static pressure is higher in a channel with a double step, and both the losses of total pressure and the rate of increase in losses are lower than in a channel with a single step. Thus abrupt expansion in the form of two steps that are symmetric relative to the middle plane is more effective than a single step. Figures 2, references 11: 3 Russian, 8 Western. [137-6610]

UDC 621.59:534.1:546.291

#### STABILITY BOUNDARY OF THERMALLY DRIVEN OSCILLATIONS IN PIPELINE OF VARIABLE CROSS SECTION

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 46, No 1, Jan 84  
(manuscript received 30 Jul 82) pp 31-35

SYSOYEV, V.A. and GORBACHEV, S.P., Balashikha Scientific Production  
Association of Cryogenic Machine Building imeni the Fortieth Anniversary of  
the Great October Revolution

[Abstract] Thermally driven oscillations may arise in a nonisothermal tube with one end closed while the other end is located in a cryostat with liquid

helium. As a result, the heat influx to the helium increases by a factor of ten or more. One way to study this effect is to determine the range of parameters of the system where such oscillations may occur, i.e., to find the necessary condition for onset of oscillations or solutions of the stability problem. The problem has been previously analyzed for pipes of fixed cross section. In this paper, the authors study the stability of oscillations in tubes with radius that varies with tube length, and in particular for a stepwise increase in radius, which corresponds to a pipeline made up of pipes of different diameters, or to the case where closed vessels are connected to the ends of the line. An equation is derived for nonisothermal oscillations of gas in such a system, enabling determination of the limit of stability of these oscillations. It is theoretically and experimentally shown that an increase in radius or connection of a vessel to the warm end of the line has a dual effect. On the one hand, there is a considerable reduction in the stability limit, and on the other hand the oscillations damp out with further flaring. It is experimentally demonstrated that oscillations can be thermally induced in helium in a pipe cooled to about 80 K at one end while the other end is held at about 250 K. It had been assumed heretofore that a temperature ratio of at least 5.5 was needed to stimulate such oscillations. Figures 4, references 7: 3 Russian, 4 Western.  
[137-6610]

UDC 533.72(083.5)

#### MUTUAL DIFFUSION COEFFICIENTS OF SOME BINARY GAS MIXTURES

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 46, No 1, Jan 84  
(manuscript received 10 May 82) pp 44-50

POZHAR, L.A. and SHCHELKUNOV, V.N., Physicotechnical Institute of Low Temperatures UkSSR Academy of Sciences, Kharkov

[Abstract] The solution of practical problems in cryogenic engineering involving processes of mass transfer, requires knowledge of the mutual diffusion coefficients of gas mixtures in the temperature range of 100-300 K. The classical kinetic theory of gases is applicable to description of transfer processes in He, Ar, CO<sub>2</sub>, O<sub>2</sub>, and N<sub>2</sub> in the given temperature range at pressures up to 10<sup>6</sup> Pa. In this paper, the authors calculate the mutual diffusion coefficients of binary mixtures of these gases in this temperature range, and also determine the self-diffusion coefficients of the individual gases in the first Chapman-Cowling approximation for the Lennard-Jones potential (6-12). The discrepancy between theoretical and experimental results ranges from 3 to 10%, depending on the type of mixture. Figures 4, references 41: 17 Russian, 24 Western.  
[137-6610]

## COEFFICIENT OF SURFACE FRICTION WITH TURBULENT FLOW IN BOUNDARY LAYER

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 46, No 1, Jan 84  
(manuscript received 22 Jul 82) pp 51-56

KAPINOS, V.M., Kharkov Polytechnical Institute

[Abstract] A large body of experimental data has amply demonstrated that the two-parameter Thompson equation is the best of the known expressions that describe velocity distribution in a turbulent boundary layer with gradient flow. The law of friction corresponding to a two-parameter family of profiles is represented by Thompson as a grid of curves plotted by graphic interpolation of experimental data and results of theoretical analysis. The lack of an analytical description of the law of friction is an impediment to use in boundary layer calculations. Taking a previously proposed approximation of the Thompson "weighting" function and an algebraic expression for a family of velocity profiles as a basis, the authors propose a system of two equations describing the friction law in implicit form as a dependence of the friction coefficient on the form factor  $H$  and the Reynolds number  $Re_\theta$  taking the thickness of momentum loss as the characteristic linear dimension. The graphic Thompson relation is reconstructed by using these equations. To simplify calculations, an approximation of the solution of the equations is given that is valid over a wider range of form factors  $H$  and Reynolds numbers  $Re_\theta$  than the Ludwig-Tillman relation. Figures 2, references 22: 9 Russian, 13 Western.  
[137-6610]

## REGION OF EXISTENCE, TRUE VOLUMETRIC PHASE CONCENTRATIONS AND HYDRAULIC DRAGS FOR ANNULAR FLOW STRUCTURE OF GAS-LIQUID MIXTURES IN PIPES

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 46, No 1, Jan 84  
(manuscript received 24 Sep 82) pp 64-70

YELIN, N.N., Ivanovo Power Engineering Institute imeni V.I. Lenin

[Abstract] The author studies the true volumetric phase concentrations and hydraulic drags in gas-liquid flows with annular structure. The true volumetric concentrations were measured during movement of the mixtures in glass tubes with inside diameter of 15.2 and 32.7 mm at velocities of the mixture from 3 to 17 m/s over the entire range of variation in slope of the pipe to the horizontal from vertically descending to vertically ascending. The viscosity of the liquid phase ranged from  $10^{-3}$  to  $22.1 \cdot 10^{-3} \text{ N}\cdot\text{s}/\text{m}^2$ . The true content of liquid was measured by the method of cutoffs. The transition from annular flow structure to plug flow was determined from the change in the dependence of the true volumetric content of fluid on the criteria of two-phase flow. It is shown by a direct experimental check that generalization of experimental data necessitates the use of parameter that is the product

of the Reynolds and Froude numbers. Hydraulic resistances were measured on horizontal tubes with inside diameter of 9.1, 15.2 and 32.7 mm. The velocity of the mixture was varied from 8 to 30 m/s, and the viscosity of the liquid phase was varied from  $10^{-3}$  to  $104 \cdot 10^{-3}$  N·s/m<sup>2</sup>. The results were processed in terms of adjusted hydraulic drag coefficients. The proposed method enabled generalization of experimental data obtained over the entire range of variation in pipe diameters, mixture velocities and viscosities of the liquid phase, as well as data of other studies on hydraulic drags of steam-water flows at high pressure. Figures 4, references 13: 11 Russian, 2 Western. [137-6610]

UDC 536.423.1:531.15

#### PROCESS OF LIQUID BOILING IN ROTATING VESSELS AND CHANNELS

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 46, No 1, Jan 84  
(manuscript received 13 Jul 82) pp 100-108

SERGEYEV, S.I., POPOV, O.M. and VISHNEV, I.P., All-Union Scientific Research Institute of Helium Technology, Moscow

[Abstract] Experiments are done on visual observation of convection and boiling of water in glass rotating vessels and channels of various shapes. The parameters of the experimental stand were as follows: radial distance from the bottom of the vessel or wall of the channel to the axis of rotation about 12 cm, radial distance from the edge of the vessel or beginning of the channel to the axis of rotation 2 cm, channel diameter 0.3 or 0.5 cm, vessel diameter 4 or 7 cm, the heater was an outer heated sleeve around a section of channel 8 cm long, or a flat heater on the bottom of the vessel 3 cm in diameter covering 18-50% of the bottom area. Speed of rotation was 1500 rpm or less. Visual observation was by stroboscopic illumination of bubbles and plastic chips with density near that of water, and also by photography. Speed of rotation and thermal power of the heater were measured. The results show the following sequence of modes with increasing thermal power. 1. Intense circulation of single-phase heated liquid with temperature below the boiling point. 2. The same circulation accompanied by boiling in the zone near the axis of rotation outside of the region of heating. 3. Expansion of the zone of boiling and approach to the heater, which is accompanied by relaxation of the rate of circulation. 4. Extension of the boiling zone to the heating surface, beginning on the low-head side of the vessel or channel, and fractionation of the circulation into chaotic jets or chains of vapor bubbles. Figures 3, references 10: 8 Russian, 2 Western. [137-6610]

UDC: 539.23

CHARACTERISTICS OF STRUCTURAL FORMATION OF NITRIDE SYNTHESIZED BY LASER ACTION UPON METALS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 5, Oct 83  
(manuscript received 19 Apr 83) pp 1110-1114

RYKALIN, N.N., Academician, UGLOV, A.A., GREBENNIKOV, V.A. and IGNAT'YEV, M.B.

[Abstract] The connection between self-sustained oscillatory processes in laser plasma near the surface and the formation of nitride structure on the surface of a metal is established experimentally for the first time. The principles by which the irradiation conditions and method of delivering nitrogen to the target influence the structure and properties of nitride compounds synthesized on the surface of high-heat metals are also identified. A neodymium laser with flux density of  $q=10^5=10^7$  W/cm<sup>2</sup> and pulse length of  $\tau=1$  s is focused on the surface of cast titanium specimens. Nitrogen was delivered to the surface of the target in two different ways. The kinetics of the phenomena occurring in the affected zone are discussed. The formation of multilayered nitride structures on the surface of high heat metals can be viewed as indirect confirmation of the existence of self-sustained oscillations in the laser beam-plasma-target surface system. References 6 Russian.  
[118-6900]

IMPROVING ENERGY PERFORMANCE AND DUTY TIME OF PRODUCTION PROCESS CW ELECTRICAL IONIZATION CO<sub>2</sub> LASERS BY USING FIVE-COMPONENT LASING MIXTURES

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОЙ ФИЗИКИ in Russian Vol 9, No 20, 26 Oct 83 (manuscript received 21 Jul 83) pp 1224-1228

AVERIN, A.P., BASOV, N.G., GLOTOV, Ye.P., DANILYCHEV, V.A., KERIMOV, O.M., MALYSH, M.M., SOROKA, A.M., TSEPELEV, V.Ye. and CHEBURKIN, N.V., Physics Institute imeni P.N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] The effort to extend the operating time of industrial lasers without replacing the lasing mixture has focused attention on the addition of gas mixtures capable of eliminating negative ions. This paper describes an experimental study of an electrical ionization CO<sub>2</sub> CW laser to determine

the optimal mixture composition. The use of five components in the lasing medium,  $\text{CO}_2:\text{CO}:\text{N}_2:\text{Ar}:\text{He}$  at concentrations of  $[\text{CO}]$  approximately equal to  $[\text{CO}_2]$  and  $[\text{Ar}]$  greater than or approximately the same as  $[\text{He}]$ , makes it possible to attain physical efficiency of 13% with a specific volumetric energy output of  $Q_v = 2 \text{ KW/m}^3/\text{sec}$  during CW operation for several hours. This is significantly higher than the parameters achieved using traditional three-component ( $\text{CO}_2:\text{N}_2:\text{He}$ ) mixtures at the present time. The evolution of the beam current density for a  $\text{CO}_2$  laser with a nominal power of 10 KW is plotted for various component ratios as a function of time between 0 and 3 hrs; a nearly flat curve increasing from about  $4 \mu\text{A/cm}^2$  to  $5 \mu\text{A/cm}^2$  over 3 hrs is obtained for a  $\text{CO}_2:\text{CO}:\text{N}_2:\text{Ar}:\text{He}$  ratio of 1:5:5:5:4. Figures 2, references 8: 6 Russian, 2 Western.  
[16-8225]

UDC 539.3:621.375.826

#### THERMOELASTIC STABILITY OF COOLED LASER MIRRORS

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 45, No 4, Oct 83  
(manuscript received 14 Jun 82) pp 640-646

KHARITONOV, V.V. and KOSHELEV, S.B.

[Abstract] The thermoelastic stability of laser mirrors is analyzed, considering a flat circular disk of uniform thickness as the simplest form of such a mirror: its front surface heated by incident radiation of uniform intensity, its back surface cooled at a constant rate of heat transfer to the coolant. The thermoelasticity problem of a thin plate is solved for two extreme mirror mountings: 1) free support on a rigid base; 2) rigid clamping around the periphery. The critical thermal strains and the fracture threshold are determined for the first case, the critical thermal stresses and the flexural instability threshold are determined for the second case, under continuous and under pulse loads in each case. The results are applied to the design of cooling in terms of coolant pressure head and filtration velocity. Numerical data have been obtained for aluminum, copper, tungsten, invar mirrors with solid or various forms of porous structure. Figures 2, table 1, references 6: 5 Russian, 1 Western.  
[93-2415]

UDC 621.378.3

#### PASSIVE SHUTTERS USING No. 1000 DYE FOR PICOSECOND LASER EQUIPMENT

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 27, No 9, Sep 83  
(manuscript received 9 Nov 82) pp 809-812

MIKHAYLOV, V.P., DEMCHUK, M.I., YUMASHEV, K.V. and AVDEYEVA, V.I., Scientific Research Institute of Application Problems in Physics imeni A.N. Sevchenko

[Abstract] Several dyes have been studied experimentally as saturable absorbers for possible application in lasers with passive mode locking. These dyes

included No. 1000 (anion-iodine) and its anion-type analogs  $\text{BF}_4^-$ ,  $\text{ClO}_4^-$ ,  $\text{Ts}^-$  in acetone, 1,2-dichlorethane, and ethanol solutions, with YAG:Nd as the active laser element. The duration of ultrashort pulses was measured by the method of second-harmonic generation in an  $\text{LiNbO}_3$  crystal. The energy of ultrashort pulses was measured with an IMO-2 instrument. Absorption and luminescence spectra were recorded, the cross section for absorption was measured at the peak wavelength and at the emission frequency, the transmission coefficient of each solution was reduced to the threshold value for given pumping energy and resonator characteristics. Also the number of pulses per train and the photostability of the dye solutions were determined. The results indicate the feasibility of using No. 1000 dye as well as its analogs for mode locking, these materials not having been used before for this application. The authors thank N.V. Monich for synthesizing the analog dyes. Article was presented by Academician (BSSR Academy of Sciences) M.A. Yel'yashevich. Figure 1, table 1, references 5 Russian.  
[88-2415]

UDC 621.373.535

#### PASSIVE Q-SWITCHING OF LASER RESONATOR USING ALKALI-HALIDE CRYSTALS WITH Z-CENTERS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 6, Dec 83  
(manuscript received 1 Feb 83) pp 1118-1119

SOBOLEV, L.M., PENZINA, E.E., PARFIANOVICH, I.A., BRYUKVIN, V.V. and VARNAVSKIY, O.P.

[Abstract] A feasibility study was made of passive Q-switching of laser resonator using alkali-halide crystals with Z-centers. Crystals of NaCl, KCl, KBr, KI, RbCl, RbBr were grown by the Kyropoulos method and doped with Ca, Sr, Ba, or Eu. These crystals were then additively tinted by heating in vapor of an alkali metal, resulting in formation of  $Z_2$ -centers. Crystals of RbBr < Ba > were used for Q-switching, at repetition rates of 12.5-100 Hz, the resonator of a neodymium laser emitting gigantic radiation monopulses (wavelength  $\lambda = 1.06 \mu\text{m}$ , energy 0.14 J in free-emission mode and 0.01 J in Q-switching mode, duration 20 ns in Q-switched mode). Crystals of RbBr < Ba > and KBr < Eu > were used for Q-switching the resonator of a ruby laser emitting giant monopulses (wavelength  $\lambda = 0.694 \mu\text{m}$ , energy 0.23 J in free-emission mode and 0.02 J in Q-switched mode, duration 20-30 ns in Q-switched mode). The crystals operated effectively for  $10^7$  pulses of the neodymium laser and for  $10^3$  pulses of the ruby laser without degradation of their properties. The crystals were also found to be usable with these two lasers for mode locking. Figure 1, references 3 Russian.  
[122-2415]



## DEPENDENCE OF SHAPE OF LASER-EXCITED ELASTIC PULSES ON RADIATION WAVELENGTH

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 30, No 1, Jan-Feb 84  
(manuscript received 14 May 82) pp 5-9

ARKHIPOV, V.I., BONDARENKO, A.N. and KONDRAT'YEV, A.I., "Dal'standart"  
Scientific-Industrial Association

[Abstract] The dependence of laser-excited elastic pulses, specifically their shape, on the absorption coefficient  $\gamma$  of the medium and thus on the wavelength  $\lambda$  of the radiation is analyzed on the basis of corresponding equations of thermoelasticity. A laser pulse with axisymmetric distribution of luminous energy is assumed to impinge on the free surface of an elastic half-space, without heat transfer from the latter to the ambient medium taking place. These equations are solved, with the aid of Laplace transformation, for zero-value initial conditions and appropriate boundary conditions. The theoretical results have been verified experimentally, using a ruby laser ( $\lambda = 694$  nm, pulse duration 30 ns) and a YAG laser ( $\lambda = 1.06$   $\mu$ m, pulse duration 10 ns). An acoustic plate was used as the absorbing medium and a laser interferometer was used for measuring waveform distortions in the excited elastic pulse. The results should be useful for design and performance analysis of laser-acoustic device. Figures 6, table 1, references 5 Russian.  
[90]2415]

UDC 521.373.826

## IRIS PULSING RUBY LIGHT SOURCE

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 4, Oct 83  
(manuscript received 25 Oct 82) pp 684-687

MORGUN, Yu.F., MURAVITSKIY, M.A. and LAVROVSKIY, L.A.

[Abstract] The new patented and built IRIS ruby laser emits either nanosecond or microsecond light pulses for high-resolution holography and spectroscopy, also suitable for holographic interferometry, lidar and other applications. Its optical equipment includes a gas laser for convenient adjustment of resonator components and alignment of the main laser beam. Its electrical components include two power supplies, each for one of the IFP-1200 flash lamps pumping the laser. Results of tests and measurements indicate that radiation from this device has a high degree of space coherence and stable spectral characteristics. This laser can operate in two monopulse modes A (pulse duration 50-150 ns, energy 0.5-1.2 J/pulse, width of emission line 30-150 MHz) and B (pulse duration 30-100 ns, energy 2.5 J/pulse, width of emission line 200-300 MHz) as well as in the free emission mode (pulse duration 600-800  $\mu$ s, energy 8-10 J/pulse, width of emission line 600 MHz), at a repetition rate of 0.1 Hz and with a beam divergence angle of 10-25' in each

mode. It has been used experimentally for various purposes, including study of substances by the method of stimulated Brillouin scattering with narrow-spectrum radiation. Operation of this laser requires eye protection. Figures 4, references 6 Russian. [29-2415]

UDC 621.378.33

#### GAIN OF WAVEGUIDE CO<sub>2</sub> -LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 4, Oct 83  
(manuscript received 15 Jul 82) pp 563-567

KORNILOV, S.T. and CHIRIKOV, S.N.

[Abstract] An experimental study was made of noncirculation-waveguide cw CO<sub>2</sub>-lasers, for the purpose of determining the gain at the center of lines of active transitions, with the active cell containing <sup>13</sup>C<sup>16</sup>O<sub>2</sub> and <sup>12</sup>C<sup>18</sup>O<sub>2</sub> isotopes respectively in the mixture. The gain was measured by the method of calibrated insertion losses, with a plane-parallel plate obliquely inserted in the resonator cavity. Two angles of plate inclination  $\theta_1, \theta_2$  to the resonator axis were recorded, each corresponding to cutoff with the length of the discharge gap  $L_1, L_2$  respectively. The gain was then calculated according to the relation  $g_0 = \frac{1}{L_2 - L_1} \ln \frac{T(\theta_1)}{T(\theta_2)}$ , with the transmission

function  $T(\theta)$  at each of these angles depending on the respective reflection coefficient, insertion phase shift, and distance between neighboring beams after multiple reflection by the plate faces. Measurements were made over the 9.1-11.2  $\mu$ m range of wavelengths, using the multicomponent mixture Xe:N<sub>2</sub>:CO<sub>2</sub>:He = 1:2:4:12 under optimum conditions for the EH<sub>11</sub>-mode. The results reveal that at each transition in any one CO<sub>2</sub> isotope molecule the gain reaches its maximum at the same pressure, 75 torr for <sup>13</sup>C<sup>16</sup>O<sub>2</sub> and lower for <sup>12</sup>C<sup>18</sup>O<sub>2</sub> because of faster <sup>16</sup>O - <sup>18</sup>O isotope exchange reaction in <sup>12</sup>C<sup>18</sup>O<sub>2</sub>-lasers than in low-pressure <sup>13</sup>C<sup>16</sup>O<sub>2</sub>-lasers. Figures 3, references 12: 7 Russian, 5 Western. [29-2415]

UDC 621.372

#### DYE-LASER FREQUENCY CONVERTER WITH TELESCOPIC RESONATOR

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 84  
(manuscript date not given) pp 47-52

GAVRILOV, O.D., GRATSIA NOV, K.V., YEREMENKO, A.S., LAN'KOVA, S.M., MALININ, B.G. and STEPANOV, A.I.

[Abstract] The performance characteristics of a dye-laser frequency converter with flat resonator and with telescopic resonator were measured, for a comparative evaluation, using rhodamine-6G or "11 B" dye as active medium.

The source of second-harmonic pumping was an  $\text{Nd}^{3+}$ -glass laser, followed by a KDP crystal with "oee" interaction as nonlinear element, a filter, and a wedge. The flat resonator had a plane exit mirror, the telescopic resonator had a convex exit mirror, the laser beam after frequency conversion was extracted from both either symmetrically or asymmetrically. Measurements were made with calorimeters and on an STE-1 spectrograph. The results reveal that using a telescopic rather than flat resonator decreases the divergence angle and thus increases the intensity of the extracted laser beam, especially at high pumping power density, without change or with slight decrease of the conversion efficiency. The authors thank V.A. Fromzel' for stimulating discussion. Figures 3, table 1, references 13: 12 Russian, 1 Western.

[61-2415]

UDC 621.375.8:535.37:541.571.9

#### LASING OF COMPLEXES WITH HYDROGEN BOND OF 7-DIETHYLAMINO-4-METHYLCOUMARIN

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 83  
(manuscript received 28 Jun 82, after completion 2 Aug 83) pp 52-58

KRASHAKOV, S.A., AKIMOV, A.I., KOROL'KOVA, N.V., DENISOV, L.K. and  
UZHINOV, B.M.

[Abstract] An experimental study was made of the effect of complexes with hydrogen bond on the laser radiation from organic compounds. The active substance were 7-diethylamino-4-methylcoumarin of "quantum electronics" grade in pure or chemically pure solvents, protonic solvents (alcohols, aliphatic acids, water) and aprotic solvents (hydrocarbons). Solution of quinine in 0.1 N  $\text{H}_2\text{SO}_4$  was used as reference standard for determining the quantum yield of fluorescence and the method of phase fluorometry with an SLM 4800S nanosecond spectrofluorometer was used for measuring the fluorescence lifetime, within 0.1 ns accuracy. The test results have been interpreted according to the theory of dye lasers and with the aid of known data on luminescence and absorption spectra of coumarin-I in the various solvents. These results indicate that complexes with a hydrogen bond to the carbonyl group in a coumarin molecule form whether the solvent is protonic or aprotic with proton donor additive. While the quantum yield of fluorescence is lower, the efficiency of laser emission is higher and the emission spectrum is wider in protonic than in aprotic solvents. Figures 3, tables 2, references 15: 10 Russian, 5 Western.

[61-2415]

# VALIDITY LIMITS FOR METHOD OF STATISTICAL MOMENTS IN TRANSIENT-STATE THEORY OF LASERS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 84  
(manuscript received 18 Oct 82) pp 151-153

KAZBERUK, A.V. and KARPUSHKO, F.V.

[Abstract] Theoretical analysis of the spectrum kinetics of tunable lasers by the method of statistical moments is considered, the problem being to establish the conditions under which the spectral density distribution of emitted radiation has such moments. The fundamental differential equation for the rate of change of radiation density, including gain and loss factor as functions of frequency as well as Einstein spectral coefficients for stimulated transitions, is integrated with respect to time. The resulting expression is further evaluated with regard to media most suitable for intracavity or extracavity laser spectroscopy, namely organic dye solutions and crystals with color centers. The results reveal that the intensity integral, which contains the probability integral in the exponent, is continuous with respect to time. Also the two definite integrals of populations, at upper and lower laser levels respectively, are continuous functions of their upper and lower integration limits. Therefore, over any finite time the spectral density distribution of emitted laser radiation always has statistical moments of orders  $n < \infty$ . This applies to sweep lasers as well as to lasers with fixed tuner setting. References 7: 6 Russian, 1 Western.  
[61-2415]

UDC 621.375.8

## DYE LASER WITH DISTRIBUTED FEEDBACK AND WITH PUMPING BY COPPER-VAPOR LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 4, Oct 83  
(manuscript received 5 Jul 82) pp 548-552

MIRZA, S.Yu., SOLDATOV, A.N. and SUKHANOV, V.B.

[Abstract] An experimental study was made for determining the characteristics of dye lasers with distributed feedback, not requiring intricate resonator structures, and the feasibility of their pumping with radiation from a metal-vapor laser. The experiments were performed with five different dyes lasing in the yellow-red (510.6-578.2 nm) range of the spectrum: rhodamine 110, 6G, S and ocazine 17,1 in ethyl alcohol solution. The optical equipment included a copper-vapor pumping laser with the gas-discharge tube inside a telescopic resonator of the unstable type. Pumping pulses of 20 ns duration were generated at 510.6 and 578.2 nm wavelengths and a 4 kHz repetition rate. The pumping power was varied by means of an interference filter smoothly adjustable through rotation. The pumping laser beam was

focused by a cylindrical lens on the dye cell. At optimum dye concentrations, corresponding to maximum attainable emission power, dye concentrate was added into the circulation system for determining the dependence of the pumping threshold power on the dye concentration. Also measured were the dependence of the emission efficiency on the pumping power and the tuning range of each dye laser. The efficiency was found to remain constant over the pumping power range from threshold level to eight times higher level. The results reveal different angles of laser beam divergence in the vertical plane and in the horizontal plane, the divergence angle being four times larger in the vertical plane. The conversion efficiency increased, without significant changes in spectral characteristics, with a single annular reflector instead of two reflectors. Two-frequency pumping of rhodamine 6G resulted in a drop of conversion efficiency from 9 to 7% and a locking effect, two-frequency pumping of the oxazine 17+1 mixture increased the conversion efficiency from 0.2 to 0.63%. Decreasing the dye circulation rate decreased the conversion efficiency and the signal-to-noise ratio while increasing the divergence of the emitted laser beam. The authors thank S.N. Rubanov for assistance in setting up and performing the experiments. Figures 4, tables 1, references 9: 8 Russian, 1 Western. [29-2415]

UDC 621.373.8

# THEORETICAL STUDY OF OUTPUT SPECTRAL CHARACTERISTICS OF MOLECULAR LASER WITH OPTICAL RESONANCE PUMPING

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 4, Oct 83  
(manuscript received 15 Jul 82) pp 556-563

IVANENKO, M.M. and CHURAKOV, V.V.

[Abstract] The output spectral characteristics of a medium-infrared molecular pulse laser with monochromatic optical pumping, common for all transitions, and with emission at the upper rotational sublevel are examined theoretically. The model of the active medium is three rotational sublevels coupled to rotational "reservoirs" of corresponding vibrational states through nonradiative transitions. The interaction of the active medium and the electric field components is adequately described by equations for the density matrix. The problem has been solved analytically and numerically, on a computer, for an  $\text{NH}_3$ -laser emitting on the  $\alpha P(8.0)$  line ( $12.8 \mu\text{m}$ ) with pumping on the  $\alpha R(6.0)$  line. Various numbers of longitudinal modes were considered, the results for single-mode emission having been verified in a high-selectivity resonator with an auxiliary Fabry-Perot interferometer. Particularly significant is the phenomenon of frequency pull under intense excitation, the magnitude of this pull depending on the time during emission pulse evolution. In multimode emission this pull can lead to successive shifts from one mode to another, with an available possibility of changing the direction of pull. There are no experimental data available on these characteristics of medium-infrared molecular lasers with optical resonance pumping. Figures 4, references 8: 4 Russian, 4 Western. [29-2415]

## CW YAG-Nd LASER WITH PASSIVE STABILIZATION OF SELF-MODE LOCKING

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 5, Nov 83  
(manuscript received 4 Feb 82) pp 928-934

GUSEV, A.A., KRUSHALOV, S.V., L'VOV, B.V., PAKHOMOV, L.N. and PETRUN'KIN, V.Yu.

[Abstract] The authors consider the problem of stabilizing self-mode locked operation of continuously pumped YAG-Nd lasers. A theoretical analysis is made of an effective method of stabilization that uses a passive intracavity YAG-Nd element. The amplitude-phase equations for a self-mode locked laser are solved, and the solutions are studied for stability. A physical interpretation of the technique is given, along with the results of a detailed experimental study of stabilization of self-locked longitudinal modes in YAG-Nd lasers. It is shown that introducing a passive YAG element expands the region of values of parameters corresponding to stable conditions of self-mode locked operation, as well as stabilizing the time shape of the emission pulses. Figures 3, references 5: 4 Russian, 1 Western.  
[111-6610]

UDC 621.373.826.038.82.5

## ADMITTANCE OF HETEROLASERS WITH STRIP CONTACT IN CASE OF REVERSE BIASING

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 26, No 11, Nov 83 (manuscript received 13 Oct 82) pp 52-56

KARIKH, Ye.D., BELORUSSIAN State University imeni V.I. Lenin

[Abstract] An experimental study is done on the electrical properties of heterolasers based on a double heterostructure in the  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  system with wide ohmic contact to the n-region and strip contact to the p-region. The quantity  $x$  in broad-zone emitters was 0.18 or 0.30. The level of doping of emitters was  $10^{18} \text{ cm}^{-3}$  (N) and  $5 \cdot 10^{18} \text{ cm}^{-3}$  (P). The p-type active region was doped with silicon to a concentration of  $5 \cdot 10^{17} \text{ cm}^{-3}$ . The studies were done with reverse biasing, including the breakdown region. It is shown that the voltage dependence of barrier capacitance is satisfactorily described by the relation  $C_b = C_0 / (1 - V/V_c)^{1/m}$ , where  $C_0 = (50-110) \text{ pF}$ , and  $m = 2.0-2.7$ ,  $V_c$  is the contact potential difference. Capacitance  $C_0$  at zero bias is weakly dependent on frequency in the band between 660 kHz and 60 MHz. Active conductance at  $V = 0$  increases by about an order of magnitude with an increase in frequency from 15 to 60 MHz. An investigation is made of the way that the active and reactive components of admittance of the laser depend on current at fixed frequencies in the given band. It is noted that the reactive component is weakly dependent on current in the breakdown mode due to stabilization of the reverse voltage across the laser. Possible physical mechanisms responsible for the observed characteristics are discussed. Figures 4, references 12: 9 Russian, 3 Western.  
[129-6610]

## SCALED DESIGN OF PULSED GAS-DISCHARGE LASERS

Tomsk IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: FIZIKA in Russian Vol 26, No 11, Nov 83 (manuscript received 20 Jul 82) pp 111-112

KRAVCHENKO, V.F., Scientific Research Institute of Physics, Rostov-na-Donu State University

[Abstract] Previous research has shown the dimensional analysis can be used in developing principles for scaled design of pulsed gas-discharge lasers, i.e. design in which the parameters of the proposed and model lasers are proportionally dependent on the ratios of linear dimensions and pressures of the active medium of these lasers. In this paper the author calculates the main parameters of a proposed gas-discharge laser from data on the dimensional parameters of a previously studied model. The basis of the design method considered here is similarity of the plasmas of the pulsed gas discharges at the instants of lasing. The principal similitude relations of the discharge plasmas in the pulsed gas-discharge lasers are found from analysis of the kinetics of unsteady processes in pulsed gas discharges of nanosecond duration. References 5 Russian.  
[129-6610]

PROBLEMS OF EMISSION FORMATION IN TWO-PASS CO<sub>2</sub> AMPLIFIER WITH PHASE-CONJUGATE MIRROR

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 12, Dec 83 pp 2397-2407

BETIN, A.A. and SHERSTOBITOV, V.Ye., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] The authors consider an arrangement with a phase conjugator to compensate for the influence of inhomogeneities of the active medium on the spatial structure of emission in a two-pass CO<sub>2</sub> amplifier. When such an arrangement is used with CO<sub>2</sub> lasers, the duration of emission pulses usually considerably exceeds the round-trip time of light travel through the amplifier, so that waves are propagating simultaneously in both directions, with the result that nonlinear interaction of opposed waves in the amplifier itself may have a considerable effect on emission characteristics. An investigation is made of some of the problems resulting from this nonlinear interaction in regard to formation of the radiation in a two-pass CO<sub>2</sub> amplifier. Figures 4, references 12: 10 Russian, 2 Western.  
[141-6610]



## NEW TYPE OF DYE LASER WITH LIGHT-INDUCED DISTRIBUTED FEEDBACK

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 12, Dec 83 pp 2408-2414

DAS'KO, A.D., MURAV'YEV, A.A., RUBINOV, A.N. RYZHECHKIN, S.A. and EFENDIYEV, T.Sh., Institute of Physics, BSSR Academy of Sciences

[Abstract] The paper gives the results of studies of characteristics of a distributed feedback dye laser that emits a narrow line with a broad pumping spectrum, and at the same time is simple and small in size. The proposed laser comprises a cell with dye solution that has a transmitting phase holographic grating on the input face. The pumping beam is incident perpendicular to this grating, and at the output from the grating it is split into three beams corresponding to the +1, 0 and -1 diffraction orders. Substitution of a holographic phase grating for the optical arrangement ordinarily used for shaping pumping beams that interfere in the active medium drastically implies the design, and more importantly, relaxes the requirements for time and space coherence. An experimental verification of the proposed design shows that a lasing line with width of  $0.24 \text{ cm}^{-1}$  can be emitted when the width of the pumping spectrum is  $616 \text{ cm}^{-1}$ . This performance can be improved by simple modifications. Figures 6, references 11: 4 Russian, 7 Western.  
[141-6610]

UDC 621.373.826.038.824

## QUASI-WAVEGUIDE THIN-FILM TUNABLE DYE LASER

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 12, Dec 83 pp 2415-2419

ARUTYUNYAN, V.M., DZHOTYAN, G.P., KRAMENYAN, A.V. and MELIKSETYAN, T.E., Scientific Research Institute of Physics of Condensed Media, Yerevan State University

[Abstract] Leakage modes of waveguide lasers cause undesirable losses of lasing power and may lead to disruption of emission. For this reason, investigation of these modes until now for the most part has been from the standpoint of a source of unwanted losses. Very little research has been devoted to active systems having only leakage modes (active quasi-waveguides). All the same, leakage modes are of interest as a source of laser radiation, opening up the possibility of active control of lasing within the amplifying layer through external action on leakage modes. Some possible ways of realizing such a quasi-waveguide laser are considered in this paper. The laser is a plane-parallel layer of amplifying medium (dye) of given thickness between dielectric plates. The index of refraction of the active medium is less than that of the adjacent media. Such a system precludes waveguide propagation of light in the active medium by total internal reflection from its boundaries. Experimental studies were done on an active medium of rhodamine-6G (refractive index 1.365) in a special cell of fused quartz (refractive index 1.458). The laser was designed so that the thickness of

the dye layer could be varied, and the dye could be circulated if necessary. Pumping was provided by the second harmonic of a YAG:Nd laser and a molecular nitrogen laser. Figures 4, references 9: 7 Russian, 2 Western.  
[141-6610]

UDC 621.373:535

#### IMPROVING EFFICIENCY OF INTRACAVITY LASER PUMPING OF SELECTIVELY ABSORBING MEDIA

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 29 Oct 82) pp 501-506

AUBAKIROV, R.G., MURZIN, A.G. and FROMZEL', V.A.

[Abstract] An analysis is made of conditions that maximize efficiency with intracavity laser pumping of active media. It is shown that the parasitic shift of stimulated emission of the pumping laser that arises in some cases can be eliminated without detriment to the efficiency of laser pumping. An experimental study is done on two possible energy-efficient methods of stabilizing the emission spectrum of a neodymium laser with intracavity load of yttrium-erbium glass: Inserting a short-base Fabry-Perot etalon into the cavity, and using mirrors with a sharp differential of spectral characteristics as the cavity mirrors of the laser. The optimum multilayer coating for such mirrors is determined. Figures 3, references 7: 5 Russian, 2 Western.  
[144-6610]

UDC 621.373:535

#### FEASIBILITY OF IMPROVING LAMP PUMPING EFFICIENCY OF ERBIUM GLASS LASERS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 17 Nov 82) pp 583-586

LUNTER, S.G., MURZIN, A.G., TOLSTOY, M.N., FEDOROV, Yu.K. and FROMZEL', V.A.

[Abstract] Until now, the efficiency of lamp-pumped Yb-Er glass lasers has been low (of order of 0.2% or less). The authors have shown that this efficiency can be improved by two independent means: 1. increasing the duration of the pumping pulse to about  $10^{-2}$  s, leading to matching of the pumping spectrum with the absorption spectrum of  $\text{Yb}^{3+}$  ions, and the rate of excitation of  $\text{Yb}^{3+}$  ions with the rate of their deactivation by  $\text{Er}^{3+}$  ions; 2. using an additional sensitizer that is a good absorber of pumping lamp emission and that transmits excitation energy to  $\text{Yb}^{3+}$  ions without large losses. The  $\text{Cr}^{3+}$  ion was selected as such a sensitizer. Experiments were done on active elements of lead-barium-phosphate glass with activator concentrations of 17.0 wt.%  $\text{Yb}_2\text{O}_3$ , 0.25 wt.%  $\text{Er}_2\text{O}_3$ , and sensitizer concentrations of 0, 0.07 and 0.5 wt.%  $\text{Cr}_2\text{O}_3$ . The efficiency and threshold were determined for different pumping pulse durations and electric energies in the free lasing mode, and the distributions of energy input of pumping lamps with respect to the absorption bands of  $\text{Cr}^{3+}$  and  $\text{Yb}^{3+}$  ions were

determined. It was found that low concentration of chromium improves efficiency, while a high concentration reduces efficiency. The maximum improvement of lasing efficiency is realized at longer pumping pulses, where a minor role is played by additional sensitization, and a major factor is improved spectral-energy distribution of the pumping radiation for  $\text{Yb}^{3+}$  ions. The maximum efficiency of 1.2% could be improved to about 2.5% by optimizing the concentration of activators. Figures 2, references 3: 2 Russian, 1 Western.  
[144-6610]

UDC 621.373:535

#### INFLUENCE OF MAGNETIC FIELD ON CHARACTERISTICS OF COMPETITIVE RESONANCE IN RING GAS LASER WITH ABSORBING CELL

Leningrad OPTIKA I SPEKTROSKOPIA in Russian Vol 55, No 3, Sep 83  
(manuscript received 18 Nov 81) pp 586-588

KOS'MINA, M.A. and FRADKIN, E.Ye.

[Abstract] In a ring laser with absorbing cell, a bidirectional lasing peak is observed under certain conditions within the region of unidirectional lasing. It arises near the center of the absorption line due to absorption saturation and the consequent weakening of competition between opposed waves. This peak (competitive resonance) serves as a reference point for frequency stabilization of ring gas lasers, but its reproducibility is limited by shifting of the top of the peak relative to the center of the absorption line. Another interfering factor is splitting of the frequencies of opposed waves due to difference in Q and mismatch of the centers of the amplification and absorption lines. The authors consider the characteristics of competitive resonance (width, shift, contrast and range of existence) in dependence on the intensity of the longitudinal magnetic field superimposed on the active medium. The analysis shows that beyond a certain threshold magnetic field strength, the applied magnetic field can simultaneously eliminate both shifting and frequency splitting. Figures 2, references 6 Russian.  
[144-6610]

UDC 621.373:535

#### TECHNICAL FLUCTUATIONS OF GAS LASER WITH NONLINEAR ABSORPTION

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 12 Apr 82) pp 100-116

TUCHIN, V.V.

[Abstract] A nonlinear intracavity absorptive cell must be used to stabilize the optical frequency in lasers with technical fluctuations due to perturbations of the gas-discharge plasma and cavity length. The possibility for maximizing frequency stability depends on the width and intensity of the spectrum of frequency and amplitude fluctuations of the laser in the free lasing mode. Previous calculations of technical fluctuations of lasers with

nonlinear absorption are of limited value as they are applicable only to a low degree of saturation of gain and absorption. Since absorption saturation may be appreciable in such a laser even at low intensities, the author analyzes technical fluctuations of lasers with wide-ranging absorption saturation. Expressions for intensity modulation and frequency deviation in the case of harmonic perturbation of parameters on a given frequency in the steady state are generalized to the fluctuation perturbation of parameters with an assigned spectrum. Using these expressions and known relations for polarizability, equations are derived for the parameters that characterize the form of spectra of fluctuations in frequency and intensity. It is shown that the expressions of sources of fluctuations of gain and absorption differ appreciably from the case of weak saturation, while the form of these sources is unchanged for fluctuations of cavity length and losses. In contrast to the laser without selective absorption, the sources of fluctuations of gain and saturation become dependent on field intensity in the cavity, and as a result the bandwidth of fluctuations and the spectral density of intensity fluctuations on low frequencies are interrelated by a more complicated expression than in the case of a laser without absorption. Lasers with and without an absorptive cell have the same band of amplitude fluctuations when the effective excess of gain over losses is the same. However, the level of intensity fluctuations is higher in the laser with a cell. A detailed investigation is made of technical fluctuations resulting from perturbations of cavity length, gain, and selective losses. Figures 4, references 18: 11 Russian, 7 Western.

[145-6610]

UDC 621.373:535

#### GENERATION OF HARMONICS IN SYSTEMS OF FREE-ELECTRON LASER TYPE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 15 Mar 82) pp 103-108

KHALILOV, V.R.

[Abstract] In the narrow sense, free-electron laser devices consist of an undulator with steady-state periodic magnetic field depending on longitudinal coordinate along the undulator axis. A beam of relativistic electrons moves along the axis with low-amplitude oscillations in the transverse plane and along the axis. Interaction of such a system with external electromagnetic radiation results in stimulated processes that may amplify or attenuate the incident radiation. Under certain conditions, interaction of quasisrelativistic electrons with plane electromagnetic waves propagating at some angle to one another should also result in stimulated emission of electrons, with amplification of one wave, while the other is attenuated. In this case, the photons of one of the waves undergo stimulated Compton scattering by an electron, producing photons that are emitted into the other wave. Such a system is called a Compton laser. The analogy between processes in free-electron and Compton lasers is especially close when the velocity of electrons in the undulator along the axis is close to that of light. In this case, the method of equivalent photons can be used to calculate the power of stimulated emission in the free-electron laser in the

linear approximation with respect to incident radiation. The author uses this approximation in considering stimulated emission of relativistic electrons in systems of the free-electron laser type on harmonics that are multiples of the fundamental frequencies that typify these systems. The calculations are based on kinetic relations for processes of stimulated emission and absorption of photons by relativistic electrons moving the electromagnetic field of an undulator. The analysis covers stimulated emission of electrons moving in a helical undulator, a flat undulator with piecewise-constant magnetic field, and stimulated scattering of a plane wave by electrons moving along the lines of force of a constant magnetic field. References 20: 12 Russian, 8 Western.  
[145-6610]

SELF-QUENCHING PERIODIC-DUTY PULSE REACTOR

Tbilisi SOOBASHCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian Vol 112, No 1, Oct 83 (manuscript received 17 Sep 82) pp 125-128

KOCHENOV, A.S., Institute of Atomic Energy imeni I.V. Kurchatov, USSR Academy of Sciences, and KIKNADZE, G.G., Institute of Physics, GSSR Academy of Sciences

[Abstract] The feasibility of operating various research pulse reactors (IGR, IIN, IBR-2) in the self-quenching mode has been extensively studied in experiments with neutron spectroscopy by the time-of-flight method. According to the main pulse quality indicator, namely the ration of flux density of thermal neutrons to pulse duration squared, none of those reactors is adequate. The pulse quality indicator is evaluated on the basis of the equation for the rate of change of the specific power without including the negligible contribution of delayed neutrons. In self-quenching reactors which operate at high pulse repetition rates the pulses can be quenched as consequence of the Doppler effect and the decrement of supercriticality is almost proportional to the specific energy release. Taking this into account, a heterogeneous reactor of the IBR-2 caliber with  $UO_2$  fuel elements in steel jackets is proposed for neutron spectroscopy in the self-quenching mode, with light water serving as both reflector and coolant. Such a reactor can deliver thermal neutrons to the reflector in  $4 \cdot 10^{21} n / (cm^2 \cdot s^3)$  pulses of 340  $\mu s$  duration at a repetition rate of 1 Hz, with a  $1.3 \cdot 10^{18} n / (cm^2 \cdot s)$  flux intensity at the pulse peak and with an average power of 100 MW. This reactor will burn 3000 times less fuel per unit time than does a stationary reactor of equal power. It will also be much safer than the IBR-2 reactor. Article was presented by Academician V.I. Gomelauri on 29 July 1982. References 5 Russian.  
[97-2415]

## ANNIHILATION ACCELERATION OF MACROPARTICLES FOR CONTROLLED NUCLEAR FUSION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 1, 1984  
(manuscript received 30 Jan 83) pp 68-71

GOREV, V.V., Institute of Atomic Energy imeni I.V. Kurchatov, Moscow

[Abstract] This work discusses the problems of accelerating a small particle to 100-1000 km/s in a relatively short path while maintaining its temperature at some tenths of an electron volt in order to achieve nuclear fusion by impact of the small particle (macron) with a massive wall. The acceleration system discussed is based on the phenomenon of annihilation of positrons with the electrons of the substance of these macrons. The thought experiment assumes that the macron is bombarded by a beam of positrons which are present in the specimen for a time longer than the characteristic annihilation time for the material of the specimens, forming gamma quanta which depart from the specimen so that the surface is positively charged. The surface breaks up and the products are accelerated in the electrostatic field of the macron, imparting an acceleration. The necessary positron beam energy is calculated. References 10: 7 Russian, 3 Western.  
[25-6508]

UDC: 531.9

## MEASUREMENT OF PARAMETERS OF HIGH CURRENT ELECTRON BEAM BY SCATTERING

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 1, 1984  
(manuscript received 4 Jul 83) pp 66-67

ALEKSANDROV, A.F., GALUZO, S.Yu., ZHURAVLEV, V.A., KARPOV, O.V., KUZNETSOV, V.Ya., KUBAREV, V.A., MIKHEYEV, V.V., MUZALEVSKIY, V.Ye., PETROV, G.D., PLETYUSHKIN, V.A. and RUKHADZE, A.A., Physic Institute imeni P.N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Results are presented from the first successful experiments on quantitative measurement of parameters of the velocity distribution function of electrons in a high-current relativistic electron beam over the spectrum of scattered laser radiation. Equations relating the characteristics of the scattered radiation to the distribution function of electrons were used to process the experimental data. The value of  $\epsilon$  found agrees well with the accelerating voltage, indicating little sag of potential of the base charge of the beam. The results obtained indicate that the method of gathered laser radiation is highly informative and reliable for quantitative determination of the parameters of high current relativistic electron beams. Figures 2, references 7: 5 Russian, 2 Western.  
[25-6508]



## ASYMPTOTIC ANALYSIS OF GAS COMPRESSION PROCESSES IN SPHERICAL SYMMETRY

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian  
Vol 142, No 6, Nov-Dec 83 (manuscript received 10 Sep 82) pp 31-35

SVALOV, A.M., Moscow

[Abstract] In the mathematical description of target implosion in nuclear fusion with inertial containment, one approach is to use equations of an ideal compressible fluid with the equation of state of an ideal perfect gas in the model of homogeneous isentropic compression. The author considers a problem of hydrodynamic interest that arises in this approach: finding the law of motion of a piston that maximizes the integral parameter  $\langle \rho R \rangle = \int_0^R \rho dr$  at given values of the input energy and mass of imploded material. The analysis is restricted to the case of  $\gamma = 5/3$  with constant entropy over the target radius, and constant values of density  $\rho$ , pressure  $p$  and zero velocity  $u$ . It is assumed that the distribution of gasdynamic functions with respect to target radius in the final stage of compression is approximated by power-law functions, and specifically  $\rho = c/r^\alpha$ . Then the solution is self-similar in the neighborhood of the coordinate origin, and the compression process is physically realizable. Thus an asymptotic expression can be found in the center for all possible methods of compression with constant entropy. The behavior of function  $\langle \rho R \rangle$  is analyzed, assuming that the central part is described by a law with exponent  $\alpha_1$ , while the peripheral section has a different exponent  $\alpha_2$ . Analysis shows that compression is most effective when  $\alpha_2 > \alpha_1$  with a hollow target. References 7: 6 Russian, 1 Western.  
[134-6610]

UDC 535.342:666.192

EFFECT OF NEUTRON AND GAMMA RADIATION ON OPTICAL SPECTRA OF GLASS

Tashkent IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK in Russian No 5, Sep-Oct 83 (manuscript received 17 Jan 82), pp 48-51

ABDUKADYROVA, I.Kh., Institute of Nuclear Physics, UzSSR Academy of Sciences

[Abstract] Spectral characteristics of KI, KV, KU, KSSh, KSG, KSP quartz glasses under radiation in a nuclear reactor with a  $^{60}\text{Co}$  source were measured, in a study concerning the kinetics of radiative defects buildup. Photoluminescence over the 200-700 nm range of wavelengths was selected as the best indicator of induced effects, being fairly independent of the reaction process parameters and of uncontrollable impurities. The results reveal dependence of the photoluminescence intensity on the volume of glass, with an initial steep rise followed by saturation, and dependence of induced absorption on the irradiation dose. In the latter case the optical density of glass peaks at some dose of neutron or gamma radiation, simultaneous neutron and gamma irradiation having a compounding effect. The results also suggest possible overlapping of emission and absorption spectra corresponding to gamma rays and thermal neutrons, absence of a dose-power effect over the  $4 \cdot 10^{12}$ - $1.6 \cdot 10^{13}$  n/(cm<sup>2</sup>.s) range, and absence of an aftereffect for a period of about six months. It thus appears feasible to use these quartz glasses as stable dosimetric indicators in mixed n, $\gamma$ -radiation fields. Figures 2.  
[108-2415]

UDC 522.2.535.31.621.391.681.7:512.8.513

REGULAR PROCEDURE FOR CONSTRUCTING ARRAY OF NONREDUNDANT APERTURE MASKS FOR SEEING THROUGH TURBULENT ATMOSPHERE

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 10, Oct 83 (manuscript received 6 Jun 83) pp 55-58

KOPILOVICH, L.Ye.

[Abstract] Nonredundant masks for seeing through a turbulent atmosphere are conventionally constructed either by matching or according to some heuristic algorithm. Here a regular procedure is proposed, applicable to an arbitrarily large array of nonredundant nonoverlapping masks which will cover the entire

telescope aperture and the entire range of operating space frequencies. The corresponding mathematical problem is that of constructing a system of different sets which will cover a grid of integers and will contain the asymptotically complete set of intervals between grid intersections. Solution of this problem reduces to a procedure based on the Singer combinatorial theorem and on properties of finite fields. For a given  $n = q^2 + q + 1$  ( $q = p^r$ ,  $r > 1$ ,  $n$  - end of  $0, n$  grid segment) one finds a primitive polynomial  $f(x)$  of  $3r$ -th degree which is irreducible over the Galois field  $GF(p)$  and then operates with remainders. The set of differences must be tested for completeness, whereupon transition to an exactly rectangular grid is possible through appropriate exclusions and shifts. Article was presented by Academician (UkSSR Academy of Sciences) A.Ya. Usikov. Figures 3, references 6: 3 Russian, 3 Western.  
[103-2415]

UDC 621.315.592

# INTERBAND EXCITON LIGHT ABSORPTION IN THIN FILMS IN THE PRESENCE OF RESONANT LASER RADIATION

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian Vol 18, No 5, Sep-Oct 83 (manuscript received 10 May 82) pp 276-279

ARUTYUNYAN, G.M., Scientific Research Institute of Condensed Media Physics, Yerevan State University

[Abstract] A characteristic field gap appears in thin film levels which are mixed by resonant laser emissions; this gap sharply changes the electromagnetic properties of the film. The behavior of the interband absorption factor in low light when two of the closest levels are mixed together in one of the bands by such a resonant field was studied previously. At low temperatures, in sufficiently pure samples, electron--hole Coulomb interaction greatly changes this interband absorption factor. This paper analyzes the impact of the Coulomb interaction on such absorption of a weak electromagnetic field, linearly polarized in the plane of an undoped semiconductor film. The two closest levels in the conduction band in this instance are characterized by the motion of the carriers along the quantization axis which is the same as the linear polarization axis of the resonant laser radiation. The position of the absorption peaks is found to be a function of the laser field parameters, film thickness and effective permittivity. The peaks can be shifted toward both higher and lower frequencies. Increasing the coupling energy, as compared to a homogeneous sample, produces substantial resolution of discrete absorption peaks. The intensity of the main absorption line increases over the same line in a homogeneous sample; this fact can be utilized to produce tunable intense absorption and emission lines in the case of exciton recombination in a thin film. New exciton absorption processes absent in linear theory are possible in the presence of a laser field. These processes follow from general analytical equations describing the interband exciton absorption with the reradiation of a laser photon, e.g.: photon absorption at the absorption frequency from a weak field and the re-emission of a photon at the laser frequency from a strong field, the absorption of a photon at the absorption

frequency from a weak field and a photon at the laser frequency from a strong field. References 9 Russian.  
[107-8825]

UDC 537.622.3:537.635

ELECTRON PARAMAGNETIC RESONANCE AND OPTICAL SPECTRUM OF COBALT IMPURITY IONS IN  $\alpha$ - $\text{LiIO}_3$

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian Vol 18, No 5, Sep-Oct 83 (manuscript received 5 Jan 83) pp 315-317

MIRZAKHANYAN, A.A., PETROSYAN, A.K. and MALOYAN, S.G., Institute of Physics Research of the ArmSSR Academy of Sciences

[Abstract] Single crystals of lithium iodate were grown by evaporation of the solvent with  $\text{CoCl}_2$  added. The resulting crystals contained 0.001 to 0.1% Co ions. The electron paramagnetic resonance was determined using an X-band spectrometer at the temperature of liquid helium; a spectrum was observed with an effective electron spin  $S = 1/2$  with g-factor values of about 4. The inclusion of Co ions in the  $\alpha$ - $\text{LiIO}_3$  lattice in the bivalent state was also confirmed by the optical absorption spectra taken at 300 K for a sample 4.5 mm thick at wavelengths between 300 and about 1,600 nm. In addition to bands due to absorption by the  $\text{LiIO}_3$  lattice itself, two broad absorption peaks at 1,400 nm and 560 nm were also found. These values are close to the positions of absorption bands characteristic of  $\text{Co}^{2+}$  in other crystals with an octahedral surrounding oxygen configuration. Two weak peaks at 510 and 420 nm are to be assigned to spin forbidden transitions. Using analytical expressions from other literature and the measured values of the excited level energies, the splitting in the octahedral field was calculated ( $10 Dq = -8,200 \text{ cm}^{-1}$ ) as well as the Rak parameter ( $B = 810 \text{ cm}^{-1}$ ); these values are in good agreement with previous data on  $\text{Co}^{2+}$  ion levels in an octahedral field. It is shown that the impurity ion formed a paramagnetic center having axial symmetry with the nearest environment and this mechanism of  $\text{Co}^{2+}$  inclusion in  $\text{LiIO}_3$  is explained. The authors are grateful to V.A. Vazhenin and A.P. Potapov for assisting with the EPR measurements. Figure 1, references 7: 4 Russian, 3 Western.  
[107-8825]

UDC 535.2

NEW CLASS OF S-POLARIZED NONLINEAR SURFACE WAVES

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 6, Dec 83 (manuscript received 20 Dec 82) pp 1079-1081

LOMTEV, A.I.

[Abstract] The conditions for existence of nonlinear surface S-modes (E-waves) at a plane boundary between two nonlinear optically uniaxial media (half-spaces  $z > 0$  and  $z < 0$  respectively), characterized by diagonal permittivity tensors

depending strongly on the amplitude of the electric field, reveal a new class of such modes. These correspond to solutions to the Maxwell equations for quasi-monochromatic waves with "ideal" boundary conditions (equal tangential components of electric field and magnetic field, respectively, on both sides of boundary), with the requirement that the field amplitudes must be real quantities asymptotically vanishing at infinity. These modes can be excited and observed directly, without prism or periodic structure, when a finite wave is incident on the boundary between two media. The author thanks A.A. Borgardt for interest and support, K.B. Tolpygo and Yu.M. Ivanchenko for helpful discussions during seminars, and I.L. Lyubchanskiy for bringing to attention the study by A.A. Maradudin (ZEITSCHR. D. PHYSIK B, Vol 41, 1981 p 341). References 6: 4 Russian, 2 Western.  
[122-2415]

UDC 535.317.1

APPARATUS BASED ON HOLOGRAPHIC FOCUSING DIFFRACTION GRATING FOR MEASUREMENT OF DIFFRACTION EFFICIENCY OF THREE-DIMENSIONAL IMAGE HOLOGRAMS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 6, Jun 83  
(manuscript received 26 Mar 82) pp 1048-1052

PARAMONOVA, T.N. and DENISYUK, Yu.N.

[Abstract] An apparatus is proposed for quality control of photographic materials used in Lippmann holography. It consists of a holographic focusing diffraction grating as dispersive element and a selenium photocell as photoreceiver. The output signal from the latter is amplified by a special-purpose electronic circuit including a K140UD8A operational amplifier and then measured with a voltmeter. The light source is an SI6-100 photometric lamp with a ribbon filament and an EPS-132 stabilized power supply. Measuring the diffraction efficiency of three-dimensional image holograms on such materials requires a Seya-Namioka setup of monochromator and diffraction grating for minimum defocusing of the image in the exit slit during rotation of the grating and then leaving the slit in fixed position. The diffraction efficiency can be read directly and the integral diffraction efficiency can be calculated on the basis of corresponding geometrical and physical-optics relations. The spectral light-source energy distribution and the spectral photoreceiver sensitivity distribution must be known for the integral diffraction efficiency. The authors thank R.R. Gerke and T.G. Dubrovina for preparation of holographic focusing diffraction gratings on layer of chromated colloid and I.Yu. Denisyuk for designing the electronic amplifier circuit. Figures 3, references 6: 4 Russian, 2 Western.  
[122-2415]

## METHOD OF MEASURING NUMBER OF SPACE-COHERENT OPTICAL RADIATION MODES

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 6, Dec 83  
(manuscript received 15 Jun 83) pp 988-991

LESHCHEV, A.A.

[Abstract] A method is proposed for measuring the number of space-coherent modes in arbitrarily nonrandom optical radiation and thus estimating the finer structure of energy distribution between these modes. The gist of this method is passing the given radiation through a scattering phase plate and then analyzing the statistical characteristics of the spotty nonuniform speckle structure at a sufficiently far distance behind that scatterer. As theoretical basis for this method, calculations are made for a plane opaque screen with a hole through which there passes a quasi-plane wavefront with a complex amplitude which varies slowly in time and over the plane of the screen. For extending the principle to a practical experimental situation, where the modes do not differ very much from one another, relations for contrast and asymmetry of the exposure distribution are derived using the additivity of the first three central moments of the sum of independent random quantities. The author thanks V.G. Sidorovich for valuable discussions. References 9: 6 Russian, 3 Western.  
[122-2415]

UDC 535.375+535.36+621.373:535

## AMPLIFICATION OF ULTRASHORT OPTICAL PULSES DURING FORWARD STIMULATED SCATTERING

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 6, Dec 83  
(manuscript received 30 May 83) pp 985-988

GORBUNOV, V.A.

[Abstract] Amplification of a Stokes pulse during forward stimulated Raman or Brillouin scattering with complete depletion of pumping power is analyzed theoretically, considering that the excitation front for natural oscillations of the medium travels together with the pulse and acts as a screen which "rakes up" the pumping radiation. Calculations based on the equations for complex amplitudes of pumping wave, Stokes wave, and sonic wave envelopes reveal that the length of the relaxation time does not limit resulting compression, in time, of a long pumping pulse. Numerical solution of the problem confirms that the pulse parameters become almost independent of the pulse shape at the entrance sufficiently far from the latter. The results suggest interesting applications such as use of light beams with variable cross section for pulse compression and amplification without limitation by breakdown or pumping with a ramp pulse so that the Stokes pulse is amplified

with constant duration and power density. The author thanks G.N. Vinokurov and S.B. Papernyy for helpful discussions. Figure 1, references 7: 5 Russian, 2 Western.  
[122-2415]

UDC 669:539.4.01

#### TIME CORRELATION BETWEEN PROCESSES OF PHOTON EMISSION AND IRON OR Ni-Cr-Mo STEEL FRACTURE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 4, Oct 83  
(manuscript received 4 Apr 83) pp 858-860

TUPIK, A.A., VALUYEV, N.P. and MANEGIN, Yu.V., Central Scientific Research Institute of Ferrous Metallurgy imeni I.P. Bardin, Moscow

[Abstract] An experimental study was made for the purpose of establishing a time correlation between electromagnetic emission occurring during fracture and the fracture in Armco iron and in 65%Ni - 9% Cr - 4% Mo steel. The measuring equipment included a pulse amplifier, and amplitude discriminator, a photomultiplier detector, an intensimeter, a Schmidt trigger, a kipp oscillator, a pulse duration meter, a pulse counter, a 2-beam oscillograph and a fractograph. Emission was measured in three modes: analog, pulse-analog, and by count. The fractograms indicate transcrystalline brittle fracture in iron under a strain rate of 20 mm/min at -95°C. The fracture time and the emission time were both found to be much longer in Ni-Cr-Mo steel under a strain rate of 200 mm/min at 20°C, with no emission toward completion of fracture at an average rate of 14 m/s. Each process in either material is characterized by its peculiar spectrum, intensity, and duration, all of which depend on the structure and the properties of metals involved. Some estimates of the cracking rate and the emission characteristics can already be made, but new revelations of further study can hardly be predicted. Article was presented by Academician G.V. Kurdyumov on 23 March 1983. Figures 2, references 6 Russian.  
[100-2415]

UDC 621.396.962

#### HIGHER-ORDER RESONANCES IN INTRINSIC AND SCATTERED MICROWAVE RADIATION FROM SEA SURFACE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 4, Oct 83  
(manuscript received 16 Mar 83) pp 852-854

CHERNYY, I.V. and ETKIN, V.S., Institute of Space Research, USSR Academy of Sciences, Moscow

[Abstract] Telemetric ocean research by means of microwave probing involves measurement of intrinsic radiothermal radiation from the sea surface and of radiation scattered by the latter. Space and time superposition of both



measurements using one universal millimeter-wave radiometer-scatterometer facilitates the study of electromagnetic resonances associated with the gravitational-capillary region of the sea roughness spectrum. Such measurements were made during the 11th voyage of the scientific-research ship "Professor Bogorov" in the northern part of the Pacific Ocean. Microwave probing has revealed short-period (3-5 min) synchronous variations of radiometer and scatterometer signals attributable to nonstationarity of the wind fluctuation spectrum. The correlation diagram of changes in the cross section for backscattering and changes in the radio brightness temperature, both caused by wind gusts, indicates that the space component with the wavelength of sea roughness is responsible for the resonance condition. Article was presented by Academician R.Z. Sagdeyev on 28 January 1983. Figure 1, references 5: 4 Russian, 1 Western.  
[100-2415]

UDC 535.818.7:534.838

#### FEASIBILITY OF COMPENSATING RADIATION FIELD OF SOURCES BY MEANS OF PHASE-CONJUGATE MIRROR

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 4, Oct 83  
(manuscript received 11 Apr 83) pp 839-842

BUNKIN, F.V., corresponding member, USSR Academy of Sciences, and VLASOV, D.V., Institute of General Physics, USSR Academy of Sciences, Moscow

[Abstract] The feasibility of compensating the radiation field of given sources by means of a phase-conjugate mirror is established theoretically, assuming a scalar radiation field such as an acoustic one produced by sources with some space distribution at some fixed frequency. The problem is solved with the apparatus of Green functions in the approximation of Kirchhoff's diffraction theory. The dimensions of the source distribution are first considered to be arbitrary relative to the wavelength and then, more realistically, to be smaller than the wavelength while the phase distribution of sources remains arbitrary. The field is resolved into multipoles, with or without existence of a monopole. A special case is nonexistence of a dipole. The wave reflected by the mirror is generally found to have the same frequency spectrum and approximately the same space structure as the incident wave. The authors thank A.V. Gaponov-Grekhov for helpful discussion of problems arising in this study. References 5 Russian.  
[100-2415]

## RAMAN SCATTERING OF LIGHT IN ALKALI-METAL PHOSPHATE MELTS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 3, Jan 84  
(manuscript received 25 Mar 83) pp 559-561

BANISHEV, A.F., VORON'KO, Yu.K., OSIKO, V.V., corresponding member, USSR Academy of Sciences, and SOBOL', A.A., Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] A study was made of lithium and sodium orthophosphates and metaphosphates, specifically their melting and crystallization, by measuring the temperature dependence of their Raman scattering spectra. All specimens had been produced in polycrystalline form by fusion of their components in appropriate stoichiometric proportions and subsequent slow cooling. The results reveal three temperature ranges for each material: 1) ordered crystalline state with many lines in the Raman spectrum, attributable to splitting of internal vibrations in phosphate anions as well as to orientational-translational external vibration modes; 2) softening transition, attributable to and characterized by orientational disordering of  $PO_4^{3-}$  tetrahedra; 3) melt with fewer lines in the Raman spectrum, attributable to internal vibrations in "free" phosphate anions. Figure 1, table 1, references 6: 5 Russian, 1 Western.  
[110-2415]

UDC 535.212:666.22

## NEWLY DISCOVERED EFFECT OF INTERACTION OF OPTICAL RADIATION AND GLASS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 3, Jan 84  
(manuscript received 22 Mar 83) pp 568-571

GLEBOV, L.B., DOKUCHAYEV, V.G., NIKONOROV, N.V. and PETROVSKIY, G.T., corresponding member, USSR Academy of Sciences, State Institute of Optics imeni S.I. Vavilov, Leningrad

[Abstract] Mechanical stresses have been discovered in glass which build up during formation of color centers as a result of optical irradiation. These mechanical stresses were recorded by the method of photoelasticity, in the direction of the activating light beam. Color centers were produced in 30 mm thick specimens of TF10 lead-silicate glass by irradiation with the second harmonic from a YAG:Nd<sup>3+</sup> laser ( $\lambda = 0.53 \mu\text{m}$ ), emitted in pulses of 12 ns duration at a repetition rate of 12.5 Hz. The irradiation time was varied from 4 to 12 min, with the second-harmonic radiation focused through a lens on a spot 110  $\mu\text{m}$  in diameter inside a specimen. The radiation intensity was held below the level of optical breakdown in glass, absence of microdefects being monitored with an He-Ne laser ( $\lambda = 0.63 \mu\text{m}$ ), by the pattern of scattering of its radiation. The already known effects of dichroism had to be eliminated by using circularly rather than linearly polarized activating radiation. A konoscopic pattern was revealed analogous to that produced

by nonuniform axisymmetric heating of optical materials. These stresses are explained by ionization of intrinsic centers and capture of released electrons by traps, with resulting change in the charged state of centers as well as in lengths and angles of bonds around centers. These stresses are related to the radiation power density distribution and to the birefringence. The stress distribution can be calculated from the solution to the corresponding Lamé problem for a thin circular tube with infinite outside radius. Figures 2, references 10: 8 Russian, 2 Western.  
[110-2415]

UDC 539.1.074:539.194

# FEATURES OF MECHANISM BY WHICH SCINTILLATION LIGHT PULSES FORM IN HIGH-SPEED ORGANIC SCINTILLATORS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 4, Oct 83  
(manuscript received 5 Jul 83) pp 659-663

GALUNOV, N.Z.

[Abstract] The scintillation mechanism in organic scintillators is analyzed according to the J.B. Birks theory, namely assuming instantaneous ( $10^{-12}$ - $10^{-11}$ s) excitation of molecules to lower excited states. The shape of the emitted light pulse, with negligible excimer de-excitation and delayed fluorescence, is exponential. The parameters of this relation, specifically the time constants of processes involved here, have been evaluated by measurements for single-component single-crystal scintillators without luminescent additives, two-component liquid scintillators in inviscid solvents, and two-component polymer scintillators such as polyvinyl xylene with 2-phenyl-5(4-biphenyl)-oxadiazole-1,3,4(PBD). Measurements with the  $^{90}\text{Y}+^{90}\text{Sr}$  radioisotope mixture as  $\beta$ -radiation source have revealed that the time constant of transition from higher to lower excited states does not depend on the concentration of luminescent additive and that only liquid scintillators are not limited in their response speed by the excitation process and energy transfer. Figure 1, references 11: 6 Russian, 5 Western.  
[29-2415]

# OPTOACOUSTIC LASER SPECTROSCOPY OF MOLECULAR GASES AND ITS USE FOR PRODUCING SUBMILLIMETRIC LASER RADIATION AND FOR Q-SWITCHING OF CO<sub>2</sub>-LASERS

Minsk ZHURNAL PRIKLADNOY SPECTROSKOPII in Russian Vol 34, No 4, Oct 83  
(manuscript received 12 Jul 82) pp 573-580

BUGAYEV, V.A. and SHLITERIS, E.P.

[Abstract] A spectroscopic study of various molecular gases was made for the purpose of using them as source of submillimeter laser radiation, with optical resonance pumping from a CO<sub>2</sub>-laser, and as means of passive Q-switching of the latter. Their spectra were analyzed by the optoacoustic method with an acoustospectrometer for resonances between emission lines of the CO<sub>2</sub>-laser and rotational-vibrational transitions in those gases. The laser was operating in the TEM<sub>00</sub>-mode, controllable by means of an iris and tunable by means of an echelette grating. Specimens of the following substances were used in the experiment: sulfur dioxide (<sup>32</sup>S<sup>16</sup>O<sub>2</sub>, <sup>34</sup>S<sup>16</sup>O<sub>2</sub>, <sup>36</sup>S<sup>16</sup>O<sub>2</sub>); methanol and tetrahydrofuran; ethanol and its deuterium derivatives; dimethyl ether; 1,3-dioxane and 1,4-dioxane; bromoethane and iodoethane; acetic anhydride; trans-1,2-dichloroethylene. The authors thank V.A. Kudrashova for synthesizing dimethyl ether and sulfur dioxide, B.P. Fabrichnyy for synthesizing 1,3-dioxane, and Yu.F. Klement'yev for performing the mass-spectrometric analysis of the products of dimethyl ether and sulfur dioxide synthesis with the 34-isotope. Figures 4, references 12: 9 Russian, 3 Western. [29-2415]

UDC 533.9

# SPECTROSCOPIC STUDY OF RECOMBINATION PROCESSES IN WEAKLY IONIZED DECAYING PLASMAS OF INERT GASES (REVIEW)

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 84  
(manuscript received 28 Feb 83) pp 5-33

IVANOV, V.A. and PENKIN, N.P.

[Abstract] Recombination processes in weakly ionized decaying plasmas of inert gases have been studied by the spectroscopic method for about two decades. Here the main results are reviewed and discussed following a brief theoretical analysis. Distinctions are drawn between recombination of an atomic ion with an electron, occurring most effectively with participation of a third particle (atom or electron), and recombination of a molecular ion with an electron either associatively resulting in stable molecules or dissociatively resulting in an excited atom and a normal atom. Spectroscopy of these recombination processes in decaying plasmas was done for studying the kinetics of afterglow of atomic lines and molecular bands. Experiments have been performed and calculations have been made pertaining to "warmup"

and high-frequency or microwave heating of electrons, typically in a longitudinal electric field, pertaining to the temperature dependence of emission line intensity and the afterglow transient. Plasmas of helium (light gas) and neon (heavy gas) were the object of most studies, a few data have also been obtained on recombination processes in plasmas of argon, krypton, and xenon. Figures 16, tables 3, references 87: 37 Russian, 50 Western.

[61-2415]

UDC 533.9.082:621.373.826

MEASUREMENT OF GAIN IN CO<sub>2</sub> PLASMA IN WAVEGUIDE DISCHARGE CHANNEL WITH TRANSVERSE RADIO-FREQUENCY EXCITATION

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 84  
(manuscript received 10 Oct 82) pp 43-47

VOL'SKAYA, S.P.

[Abstract] Small-signal gain at P-series and R-series lines of the 00<sup>0</sup>1-10<sup>0</sup>0 transition in a CO<sub>2</sub> molecule was measured, with the active medium of a CO<sub>2</sub>-laser operating in the waveguide mode with transverse radio-frequency excitation contained in a ceramic (BeO) discharge tube. Measurements were made by the probing method with a weak signal of 2.1 W/cm<sup>2</sup>, far below the saturation level, from a stabilized CO<sub>2</sub>-laser. The latter was tuned by means of diffraction grating over the 9.6-10.8 μm range and modulated by means of a mechanical chopper at a frequency of 380 Hz. Measurements on P(6)-...-P(30) and R(4)-...-R(28) transitions in CO<sub>2</sub>:He:N<sub>2</sub>:Xe = 1:10:1:0.5 and CO<sub>2</sub>:He:N<sub>2</sub> = 1:10:1 mixtures over the 1.33-12.63 kPa pressure range, as well as theoretical calculations on the basis of the Voigt function for a weak signal at the center of an isolated vibrational-rotational emission line, reveal peaking of the gain at approximately 5.3 kPa in both mixtures. The gain was found to be maximum on the P(18) transition in the P-series and on the R(18) transition in the R-series, 1.46 m<sup>-1</sup> and 1.24 m<sup>-1</sup> respectively in the CO<sub>2</sub>:He:N<sub>2</sub>:Xe mixture and 1.32 m<sup>-1</sup> and 1.02 m<sup>-1</sup> respectively in the CO<sub>2</sub>:He:N<sub>2</sub> mixture. Figures 2, table 1, references 12: 7 Russian, 5 Western.

[61-2415]

UDC 535.361

EXPERIMENTAL STUDY OF SPECKLE STRUCTURE FORMED UPON PASSAGE OF LASER RADIATION THROUGH OPTICALLY THIN LAYERS OF FROSTED GLASSES

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 84  
(manuscript received 2 Sep 82) pp 58-65

SHCHERBAKOVA, N.I. and VOYSHVILLO, N.A.

[Abstract] An experimental study was made of the speckle structure formed by scattering of laser radiation within the bulk rather than by the rough surface

of optically nonhomogeneous media. An analysis of such a structure and its formation by a three-dimensional mechanism reveals a Wiener spectrum which depends on the geometry only and not on the microstructure of the layer, with the maximum space frequency of intensity fluctuations increasing and the minimum angular distance between intensity maxima decreasing as the layer thickness is increased. This conclusion has been verified experimentally with radiation from an He-Ne laser ( $\lambda = 632.8$  nm) and from an Ar-laser ( $\lambda = 515.0$  nm) passing through layers of type-A optically thin frosted glass (MS-18) and type-B optically thick frosted glass (MS-12/13/19/23). The parameters  $C = (\langle I_{\max} - I_{\min} \rangle) / 2 \langle I \rangle$  and  $d / d_{\min}$  (ratio of mean to minimum angular distance between intensity minima) were measured within various ranges of scattering angles  $\Delta$  in geometrically thin (0.0238-0.197 mm) and thick (2.00-50.0 mm) layers. The results confirm those of theoretical calculations, namely the regular dependence of  $d_{\min}$  on the geometrical thickness  $z$  (and thus also on the optical thickness  $\tau = \epsilon \lambda z$ , where the attenuation index  $\epsilon \lambda$  is almost equal to the refractive index  $n \lambda$  at the same wavelength  $\lambda$ ):  $1/d_{\min} = \alpha + b z$  with constants  $\alpha$  and  $b$  the same for all grades of glass but depending on the diameter of the laser beam, the wavelength of incident radiation, and the scattering angle. Figures 3, tables 4, references 6: 2 Russian, 4 Western.  
[61-2415]

UDC 535.34

# CHARACTERISTICS OF ABSORPTION OF OPTICAL RESONANCE RADIATION IN SPECTRAL LINE

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 84  
(manuscript received 4 Oct 82) pp 110-114

GORNYI, M.B., MARKMAN, D.L. and MATISOV, B.G.

[Abstract] Propagation of optical resonance radiation through optically thin and thick cells, such as used in quantum-electronic devices or found in astrophysical research, is analyzed on the basis of the transfer equation describing the radiation frequency spectrum and intensity profile. Calculations for various contours of incident and absorption resonance lines (Lorentz, Doppler, Voigt), taking into account the concentration of oriented atoms and their rate of disorientation following collisions with buffer gas atoms or molecules, reveal appreciable deviations from the classical Bouguer-Lambert law. The authors thank N.I. Kaliteyevskiy and M.P. Chayka for helpful discussion. Table 1, references 7: 5 Russian, 1 Polish, 1 Western.  
[61-2415]

RELATION BETWEEN INTENSITY AND WIDTH OF SPECTRAL LINES IN RADIATION FROM  
HOMOGENEOUS OPTICALLY DENSE PLASMA

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 84  
(manuscript received 10 Jan 83) pp 143-145

OVECHKIN, G.V.

[Abstract] A relation is established between intensity and width of a spectral line in radiation from a plasma, taking into account the temperature gradient at the boundary of hot plasma as well as the attenuation of the line intensity as a result of self-absorption coefficient, proportional to the degree of plasma nonhomogeneity and to the logarithm of atom concentration, is found to be equal to the attenuation coefficient for all lines of plasma atoms and ions except where atoms outside the plasma contribute to the attenuation (in which case it is larger than the attenuation coefficient). In the extreme case of a homogeneous optically dense plasma, without self-reversal, with the maximum line intensity reaching the Planck level the relation becomes simply  $I_0 \nu_0 = I_p \nu_\zeta$  when  $\nu_\zeta \leq 2\nu_0$  or  $I_0 = I_p e^{(\nu_\zeta / \nu_0 - 1)}$  when  $\nu_\zeta > 2\nu_0$  ( $I_0$  - line intensity without self-absorption,  $I_p$  - line intensity of Planck radiation,  $\nu_0$  - line width corresponding to optically thin plasma,  $\nu_\zeta$  - actual line width with attenuation). References 9: 8 Russian, 1 Western.  
[61-2415]

UDC 621.378.325

## NON-CONTACT MEASUREMENT OF THICKNESS WITH SHOCK WAVES EXCITED BY LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 84  
(manuscript received 12 Mar 82) pp 148-150

KOROCHKIN, L.S., KHODINSKIY, A.N. and MIKHNOV, S.A.

[Abstract] The feasibility of thickness measurement by a non-contact ultrasonic method is considered, megahertz vibrations being excited by a laser monopulse. The basis of this method is action of laser radiation on the free surface of metals and opaque dielectrics, which results in evaporation of the surface layer and plasma formation in the action zone with attendant buildup of high pressure and a shock wave within a bounded space. The method was tested experimentally on aluminum wedges, with a laser emitting pulses of 0.1 J energy and 100 ns duration, a set of three plane mirrors splitting the laser beam into two beams symmetrically striking the specimen from both sides. Ultrasonic vibrations were recorded by two piezoelectric transducers oriented normally to the corresponding two surfaces of the specimen. It must be taken into account in application of this method that the amplitude of ultrasonic vibrations and the mean velocity of a shock wave decrease while the delay time of a shock wave increases with increasing distance from the point of excitation (laser beam incidence) to the signal receiver. In using this method for remote



measurements one must take into account that the amplitude of vibrations increases to a maximum and the delay time of a wave decreases to a minimum as the energy density of the laser pulse increases, typically to  $5 \text{ J/cm}^2$ , both then remaining constant at their levels as the energy density increases further. Mechanical breakdown of the surface by shock waves can be prevented by optical breakdown of the air above with the aid of focusing lenses on both sides of the inspection sample. Figures 3, references 7: 6 Russian, 1 Western.  
[61-2415]

UDC 535.37:621.373

#### LASER-PULSE SPECTROFLUOROMETER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 84  
(manuscript received 30 Jul 82) pp 159-165

KOYAVA, V.T., SARZHEVSKIY, A.M.[deceased] and SHARONOV, G.V.

[Abstract] A laser-pulse spectrofluorometer has been built for direct and highly sensitive recording of fluorescence spectra as well as measuring of the fluorescence quantum yield and the fluorescence polarization in the presence of phosphorescence. It consists of an LG-106MI continuous-wave Ar-laser with mode locking by means of an acoustooptic Littrow-prism modulator (reflection coefficient 0.999) and with intracavity pulse extraction by means of an electrooptic modulator, a spherical mirror (reflection coefficient 0.999), a device for control of Q-factor attenuation and a device for discrete regulation of the pulse repetition rate over the 0.01-100kHz range. Spectrofluorometry of specimens in solution with this instrument is based on probabilistic analysis of pulse excitation of particles with three energy levels, fluorescence level and phosphorescence level as well as nonradiative level, namely evaluation of the probabilities of respective transitions. The performance of this instrument was tested on the emission spectra of solid solutions of acridine orange, acriflavine, erythrorosine in polyvinyl alcohol at  $20^\circ\text{C}$  and erythrorosine in ethyl alcohol at  $-196^\circ\text{C}$ . It was tested with a monochromator discriminating the luminescence from a specimen and a photomultiplier recording it in the one-electron mode. The photomultiplier output signals together with noise ("dark") pulse signals were processed by a time-to-amplitude converter operating first in the "stop" (input) mode and then in the "sample" (output) mode with time windows. The performance evaluation included an error analysis. Figures 4, table 1, references 7: 5 Russian, 2 Western.  
[61-2415]

## SOURCE OF OPTICAL PUMPING FOR HIGH-RESOLUTION SPECTROSCOPY WITH SEMICONDUCTOR LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 40, No 1, Jan 84  
(manuscript received 27 Dec 82) pp 165-167

BUDKIN, L.A., OKHOTNIKOV, O.G., PAK, G.T., PIKHTELEV, A.I. and PUZANOV, S.L.

[Abstract] A source of optical pumping for semiconductor lasers used in high-resolution spectroscopy has been built on the basis of a frequency-tunable laser diode. This diode is mounted on a heat sink inside a thermostat with temperature regulation and stabilization. Radiation emitted by this diode passes through an objective to an absorption cell containing study material, typically vapor of an alkali metal. Changes in absorption are detected by a photodetector and either chart-recorded or read on a volt-meter. The diode is energized with current of 50-200 mA from a stabilized power supply. Current fluctuations must not exceed  $10^{-3}$  mA so as to prevent them from introducing a significant error into the width of an absorption line, which requires a power supply with a relative instability not higher than  $5 \cdot 10^{-6}$ , inasmuch as a 0.02 nm/mA change in line width corresponds to a  $3 \cdot 10^9$  Hz/mA change in frequency. The thermostat temperature must be set accurately within  $0.003^\circ\text{C}$  and maintained stable within  $0.003^\circ\text{C}$ , which will ensure a 100 MHz frequency resolution, since the wavelength of radiation from a typical semiconductor laser such as GaAlAs changes at an average rate of 0.2-0.3 nm/ $^\circ\text{C}$ , or less within narrow intervals without mode skipping. This source of optical pumping was tested for total error in spectroscopy of the  $D_2$ -line in the absorption spectrum of  $^{133}\text{Cs}$ . It was found to be suitable for semiconductor lasers operating in the 700-900 nm and 1300-1700 nm ranges of wavelength. It has better performance characteristics than monochromators with diffraction gratings or standard Fabry-Perot interferometers, being furthermore much smaller and more energy efficient. Figure 1, references 16: 14 Russian, 2 Western.  
[61-2415]

## ALIGNMENT OF MULTIPLY COMPONENTS OF ATOMIC LEVELS IN COLLISIONS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 5, Nov 83  
(manuscript received 7 Jan 82) pp 819-824

PETRASHEN', A.G., REBANE, V.N. and REBANE, T.K.

[Abstract] In developing a theory of anisotropic relaxation of atomic states in gases upon collisions with a beam of neutral or charged particles, it has been demonstrated that such relaxation shows up in depolarization, and also in broadening and shifting of spectral lines. Here the authors consider a new aspect of anisotropic relaxation: alignment of the components of atomic

levels upon collisions in beams. The necessary conditions for realization of this effect are determined, and quantitative calculations of alignment are done for the case of collisions of atoms with neutral particles. The analysis shows that when excited atoms collide with a beam of neutral particles, even thermal energies are sufficient for observable alignment of multiplet components and predominance of linear polarization of light in the direction perpendicular to the beam axis. At the maximum signal of alignment, the degree of linear polarization is about 25%. The general conclusions of the theory are also applicable to the case of collisions of atoms with a beam of charged particles, and to alignment under the effect of drifting of charged particles in a plasma. Figures 3, references 13: 10 Russian, 3 Western.  
[111-6610]

UDC 539.184.28:546.11-54

#### ION OF HYDROGEN MOLECULE IN STRONG MAGNETIC FIELD

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 5, Nov 83  
(manuscript received 23 Feb 82) pp 825-832

KHERSONSKIY, V.K.

[Abstract] The author calculates the functions of potential energy of  $H_2^+$  for both the symmetric and antisymmetric state, and determines the quadrupole moment  $Q(R)$  as a function of the internuclear distance over a wide range of magnetic fields  $B$  from  $10^{10}$  to  $10^{13}$  Gs. The functions of potential energy  $U(R)$  were calculated in the adiabatic approximation by a variational method. The results show that as the magnetic field increases, there is a considerable reduction in the equilibrium internuclear distances for the symmetric configuration, while dissociation energies increase. As the internuclear distance increases, the function  $U(R)$  approaches the asymptotic value of the bonding energy of the hydrogen atom in the ground state in the magnetic field. With decreasing equilibrium internuclear distance, there is an increase in the probability of tunneling of nuclei from the molecular potential well to the potential well of the compound nucleus. Equilibrium intermolecular distances in a magnetic field of  $10^{13}$  Gs may be 0.1 Å or less, with a considerable increase in the penetration factor and tunneling probability, which could be directly related to catalysis of nuclear reactions near the surface of a neutron star. Figures 4, references 12: 4 Russian, 8 Western.  
[111-6610]

## INFLUENCE THAT CONDITIONS OF RECORDING AND RECONSTRUCTION HAVE ON ANGULAR SELECTIVITY OF HOLOGRAMS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 5, Nov 83  
(manuscript received 2 Mar 83) pp 910-917

GAL'PERN, A.D. and PARAMONOV, A.A.

[Abstract] A theoretical and experimental study is done on the angular selectivity of holograms that are used in systems for reproducing pictorial information. A comparative analysis is done on Lippmann and Gabor arrangements for recording holograms. As a result of the analysis, conditions are determined for retention of invariability of the position of reconstructed aspects with displacement of either the reconstructing beam or the hologram. It is shown that when these conditions are met, the diffraction efficiency of Lippmann holograms may have two maxima, whereas the diffraction efficiency of a Gabor hologram has only one maximum. Because of this, the angular selectivity of Lippmann holograms can be varied over a wider range than that of Gabor holograms by judicious selection of recording and reconstruction conditions. Figures 3, references 3: 2 Russian, 1 Western. [111-6610]

UDC 535.2

## THREE-WAVE PARAMETRIC MIXING OF WAVES WITH BROAD ANGULAR SPECTRA

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 5, Nov 83  
(manuscript received 29 Mar 82) pp 923-927

ARUTYUKYAN, A.G., DZHOTYAN, G.P. and MINASYAN, L.L.

[Abstract] An investigation is made of three-wave parametric mixing for phase conjugation with down-conversion of frequency in pumping, the complex amplitude of the pumping beam at the input to the medium being represented as a discrete set of spatial modes. It is shown that when certain conditions are imposed on the parameters of the pumping beam and the nonlinear medium, the image contained in a multimodal pumping beam is reproduced in the radiation of the parametrically coupled waves. The lower limit of this range is determined by the condition of compensation of the effective phase mismatch due to the difference in diffraction properties and the different "drifts" of the parametrically coupled waves. Numerical estimates for a KDP crystal show that for a pumping wavelength of  $0.53 \mu\text{m}$ ,  $\theta \approx 10^{-3} \text{rad}$  and  $k \approx 10^3 \text{ m}^{-1}$ , reproduction takes place at pumping intensities in a range of  $10^4$ - $10^8 \text{ W/cm}^2$ . References 14: 10 Russian, 4 Western. [111-6610]

# INFLUENCE THAT OPTICAL INHOMOGENEITY OF AGGLOMERATION BOUNDARY BETWEEN GLASSES HAS ON LASER EMISSION CHARACTERISTICS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 5, Nov 83  
(manuscript received 5 Nov 81) pp 940-944

MURZIN, A.G., SOLDAKOVA, N.A., FROMZEL', V.A. and TSVETKOV, A.D.

[Abstract] An experimental investigation is made of the influence that the optical inhomogeneity formed on the interface between two glasses during agglomeration has on the spatial and energy characteristics of neodymium laser emission in the case where the interface is located within the optical cavity and is exposed to the action of the field of laser radiation. The authors also study the radiation strength of agglomerated specimens of glasses that are transparent to laser radiation, but have different coefficients of thermal expansion. It is shown that two types of optical inhomogeneities may form on the interface in the agglomeration process: small-scale inhomogeneities due to dust motes, inclusions and the like that lead to overall deformation of the surface and introduce a gradient in the index of refraction, and large-scale inhomogeneities that are associated with plastic deformation of the glasses being joined with different indices of refraction, and that may also be due to imprecision in pretreatment of the glass surfaces that are being joined. To minimize the effect of optical inhomogeneity of the interface on angular divergence of emission and the energy characteristics of the laser in intracavity use, the glasses being joined by agglomeration should be selected with a difference in indices of refraction not exceeding  $10^{-3}$  (preferably no more than  $5 \cdot 10^{-4}$ ). To maximize the radiation strength relative to laser emission, the difference in coefficients of thermal expansion of the glasses joined by agglomeration should be less than  $5 \cdot 10^{-7} \text{ K}^{-1}$ . Figures 3, references 9: 8 Russian, 1 Western. [111-6610]

# INFLUENCE OF REABSORPTION ON SPECTRUM OF SUPERRADIATION AND STIMULATED EMISSION OF DYE LASER WITH LONGITUDINAL EXCITATION

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 5, Nov 83  
(manuscript received 26 Apr 82) pp 964-966

AGEYEV, L.A. and MIKOSLAVSKIY, V.K.

[Abstract] An investigation is made of the spectra of superradiation and stimulated emission and their dependence on cell thickness for an ethanol solution ( $10^{-3} \text{ M}$ ) of Rhodamine-6G in a plane-parallel cell with cavity windows of quartz and glass. Excitation was by an LGI-21 nitrogen laser (wavelength 337 nm, pulse power 1.6 kW, recurrence rate 50 Hz). The exciting radiation was focused into the solution through the quartz window by a

spherical quartz lens (focal length 5 cm) in the region near the window. The spectra were photographed on a spectrograph with linear dispersion of 1 nm/mm. Stable stimulated emission and superradiation were observed at cell thicknesses from 1 to 20 mm. At thicknesses of less than 1 mm, superradiation is absent at all angles of inclination, and stimulated emission is observed only when the cell is rotated. At thicknesses of more than 20 mm, superradiation and stimulated emission are both considerably attenuated. There is a regular shift of lasing and superradiation toward higher frequencies with decreasing cell thickness. In the 2-20 mm range, the two types of emission are separated by a constant interval of  $0.015 \mu\text{m}^{-1}$ . At thicknesses less than 2 mm, lasing and superradiation become closer. Figures 2, references 6: 4 Russian, 2 Western. [111-6610]

UDC 535, 375

# RAMAN LIGHT SCATTERING BY CRYSTALS WITH LAMINAR STRUCTURE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 5, Nov 83  
(manuscript received 31 Aug 82) pp 975-978

SHABANOV, V.F., VETROV, S.Ya. and SHESTAKOV, N.P.

[Abstract] The authors consider the particulars of Raman light scattering from crystals with periodic laminar structure and with random distribution of the thicknesses of layers. The analysis is based on an experimental study of the influence that the laminar structure of a ZnSe crystal has on intensity of Raman scattering. The average period of the structure in the direction normal to the layers was about 3  $\mu\text{m}$ . The Raman spectra were recorded in a two-beam arrangement with continuous monitoring of the power of the incident beam. Line intensities were measured in four nonequivalent geometries, and the results were compared with analogous geometries of an ideal crystal. In three configurations, the line intensities were the same for both laminar and ideal crystals. When the wave vector of the incident radiation was parallel to the plane of the layers, and the wave vector of the scattered light was normal to the plane of the layers, the laminar crystal did not show the effect of line intensity dependence on observation that is typical of piezoelectric crystals. A comparison of Raman line intensity for the laminar crystal in this geometry with the average (of two opposite directions of observation) intensity for a homogeneous single crystal showed that the intensity from the laminar crystal is about half the Raman line intensity for the homogeneous crystal. Theoretical analysis shows that this effect is due to displacement of the lattices of the succeeding layers in a laminar crystal. Estimates for ZnSe show that this displacement is about 100 Å. Figure 1, references 12: 10 Russian, 2 Western. [111-6610]

## OPTICAL CONSTANTS OF NATURAL AEROSOLS IN INFRARED SPECTRAL REGION

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 26, No 11, Nov 83 (manuscript received after revision 4 Apr 83) pp 11-14

SONCHIK, V.K., Siberian Physicotechnical Institute imeni V.D. Kuznetsov at Tomsk State University

[Abstract] When dealing with problems that involve radiation transport in the atmosphere, it becomes necessary to know the optical constants of aerosols. This paper is devoted to determination of the real and imaginary parts of the index of refraction of solid matter in natural aerosols. The samples of suspended matter were obtained by vaporization of snow or rain at 60-80°C. Dust and soot were removed by precipitation before vaporization. The dry residue was pressed onto KBr plates that were then given a mirror-surface polish. The optical constants of solid aerosols were determined by the Kramers-Kronig reflection method. The reflection spectra were recorded by a UR-20 infrared spectrometer with a special attachment enabling measurement of reflection at near-normal incidence. The reference was a KRS-5 crystal plate. Measurements were made in the spectral interval from 450 to 5000  $\text{cm}^{-1}$ . Water-soluble aerosolic matter always showed strong absorption bands and anomalous dispersion of the index of refraction of about 3400, 1640, 1100, 700 and 600  $\text{cm}^{-1}$ . Possible components of atmospheric aerosols are:  $\text{CaCl}_2$ ,  $\text{CaSO}_4$ ,  $\text{K}_2\text{CO}_3$ ,  $\text{KNO}_3$ ,  $\text{Mg}(\text{ClO}_4)_2$ ,  $\text{Na}_2\text{HPO}_4$ ,  $\text{NaHSO}_4$ ,  $\text{Na}_2\text{SO}_4$ ,  $\text{NaNO}_3$ , and  $(\text{NH}_4)_2\text{SO}_4$ . It is shown that absorption bands belonging to the same ions may be shifted in various substances due to surrounding ions of the opposite sign. The sulfates  $(\text{NH}_4)_2\text{SO}_4$  and  $\text{CaSO}_4$  are the principal components of the water-soluble part of the aerosol derived from atmospheric precipitation. A table is given summarizing data on the frequencies and coefficients of absorption (imaginary part of the complex index of refraction) in the centers of absorption bands experimentally determined in this paper and by F. Volz (APPLIED OPTICS, Vol 11, 1972, p 755), and calculated by L.S. Ivlev, V.Ye. Zuyev et al. (IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 12, 1972, p 8) for dry atmospheric aerosols. Figures 4, tables 2, references 7: 3 Russian, 4 Western.

[129-6610]

## THEORY OF UNSTEADY STIMULATED TEMPERATURE SCATTERING OF LIGHT

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 12, Dec 83 pp 2437-2439

BUNKIN, F.V., VOLYAK, K.I., LYAKHOV, G.A. and ROMANOVSKIY, M.Yu, Institute of General Physics, USSR Academy of Sciences

[Abstract] The present quasi-steady theory of stimulated temperature scattering of light gives only some time-averaged value of amplification. Unsteadiness must be accounted for in problems of energy and optimization of the effect. The authors propose an asymptotic approach to calculation of the



time parameters of stimulated temperature scattering of light that is analogous to the approach used in acoustic problems. The analysis is based on wave equations for the electric field and fluid density, the equation of thermal conductivity and the equation of state, and is limited to consideration of scattering with a small frequency shift, accounting for the dependence of permittivity on density and temperature, as well as ultimate thermal expansion. Formulas are derived that completely describe the unsteady parameters of stimulated temperature scattering for small coefficients of pumping energy conversion. It is found that there is a time scale that determines the maximum gain of the scattered wave, which has been experimentally confirmed. Figure 1, references 11: 7 Russian, 4 Western.  
[141-6610]

UDC 535.21:530.182

#### SELF-MODULATION OF LIGHT WAVES IN HOMEOTROPICALLY ORIENTED NEMATIC LIQUID CRYSTALS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 12, Dec 83 pp 2453-2463

ARAKELYAN, S.M., ARUSHANYAN, L.Ye., DALLAKYAN, A.Yu., KARAYAN, A.S. and CHILINGARYAN, Yu.S., Yerevan State University

[Abstract] The authors consider a homeotropically oriented nematic liquid crystal (director  $\vec{n}$  characterizing the average orientation of molecules in the specimen is perpendicular to the plane of the cell substrates) in a light field with different geometries. The nonadiabatic distortions of the nematic liquid crystal that arise in this case under certain conditions have not been previously studied. Consideration is taken of the reverse effect that the deformations arising in the medium have on transmission of light waves, leading to self-modulation of the transmitted waves. An investigation is also made of the dynamics of adiabatic distortion of the crystal structure in the field of the light wave. The method of calculation is based on perturbation theory; the angle of deviation of the director in the light field away from the initial orientation is taken as small. Figures 4, references 22: 18 Russian, 4 Western.  
[141-6610]



## EXPERIMENTAL STUDY OF STRONG NONLINEAR-OPTICS EFFECTS IN LIQUID CRYSTALS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 12, Dec 83 pp 2464-2475

DARBIN, S.D., University of California at Berkeley, ARAKELYAN, S.M., CHEUNG, M.M., University of California at Berkeley, and SHEN, Y.R., University of California at Berkeley

[Abstract] The authors consider some nonlinear optical effects that arise in nematic liquid crystals as a result of a change in the index of refraction induced by a laser field. Since the resultant nonlinearity is extremely high, the approximation of perturbation theory cannot be used in calculations. However, the change in refractive index results mainly in phase advance as waves propagate through a thin film of liquid crystal, while the change of intensity is insignificant. Moreover, if there is no change in polarization of the pumping field, calculations are relatively simple. An investigation is made of the propagation of a cross sectionally bounded laser beam through a homeotropically oriented liquid crystal, giving rise to spatial phase modulation of emission. When the intensity of the laser beam exceeds a certain value, a system of aberration rings is observed in the output radiation. The authors also discuss effects of dynamic self-diffraction accompanying degenerate four-wave mixing when a change in refractive index is induced in a homeotropic liquid crystal film, and optical bistability in a nonlinear Fabry-Perot optical cavity, as well as generation of a self-oscillatory state in such a resonator. Figures 9, references 37: 12 Russian, 25 Western. [141-6610]

UDC 535.37+621.373.535

## BURNOUT OF GAP WITH COMPLEX SHAPE BY COHERENT PICOSECOND PULSE TRAIN

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 12 Apr 83) pp 405-407

REBANE, A.K., KAARLI, R.K. and SAARI, P.M.

[Abstract] Photochemical burnout of a gap in the nonuniformly broadened spectra of impurity molecules at low temperatures gives good prospects for more indepth study of the physics of impurity molecules in solids and for solving applied problems such as development of optical memory elements with high-density storage capacity. Previous experimental research on burnout of the photochemical gap has assumed a steady state in burnout and registration of gaps. This paper reports burnout of a gap by a sequence of picosecond pulses, the shape of the gap reflecting phase relations between pulses that do not overlap in time. In the simplest experimental arrangement, the gap is burned out by two identical pulses separated by a given delay that are produced by dividing the beam from a picosecond dye laser in a Michelson interferometer.

In this pulse burnout process, the shape of the gap is determined by interference between a pulse and the excited state of matter produced by preceding pulses. Interference becomes possible due to the phase memory of the medium for phases of transmitted pulses. There will be no interference if the time between pulses exceeds the time of phase relaxation of the substance. Burnout of this type gives the capability of determining the fine structure of individual ultrashort pulses without disrupting their time structure. Figure 1, references 8: 2 Russian, 6 Western.  
[144-6610]

UDC 539.184:535.21

ORIENTATION EFFECT WITH EXPOSURE TO LINEARLY POLARIZED NONRESONANT LIGHT.  
II. QUANTUM MECHANICAL DESCRIPTION

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 9 Nov 81) pp 443-448

BOYARSKIY, K.K. and KOTLIKOV, Ye.N.

[Abstract] The preceding paper dealt with the classical model of the effect of circularly polarized light in a group of atoms interacting with linearly polarized nonresonant light in a magnetic field [Ye.N. Kotlikov, M.P. Chayka, OPTIKA I SPEKTROSKOPIYA, Vol 55, No 2, 1983]. In this paper the authors calculate the signal of orientation for this case, and also for the case where orientation of the system arises due to the dynamic Stark effect, which is a case that has not been discussed in the literature. The effect of transition of orientation to alignment and back is analyzed for a group of stationary atoms in the formalism of quantum mechanics. It is shown that excitation of such a system by linearly polarized nonresonant light gives rise to transverse orientation as well as alignment of longitudinal orientation. The constants of relaxation of alignment and orientation can be determined in a single experiment by using a magnetic field to break up alignment and transverse orientation. Figures 2, references 9: 6 Russian, 3 Western.  
[144-6610]

UDC 535.317.1

PECULIARITIES OF HOLOGRAPHIC AND SPECKLE INTERFEROGRAMS PRODUCED UPON  
REGISTRATION OF OBJECT LIGHT FIELD IN FOURIER PLANE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 2 Dec 81) pp 483-489

KLIMENKO, I.S., RYABUKHO, V.P., FEDULEYEV, B.V. and LOKHOVA, N.V.

[Abstract] A method of speckle interferometry is developed and generalized that is based on registration of the speckle pattern in the Fourier plane, and consideration is given to the feasibility of using an analogous approach in holographic interferometry, including for independent measurement of strain

of an object in the presence of translational displacement. It is shown that judicious choice of the plane of registration between the Fourier plane and the image plane can compensate for either translational displacement or inclination of the object. This capability can be extended to the case of longitudinal translational displacement of the object. In this case, when the object is illuminated by a spherical wave, its Fourier transform is also shifted in the longitudinal direction, leading to decorrelation of the recorded speckle structures, with a resultant decline in contrast of the speckle interference patterns. However, with plane-wave exposure the Fourier transform in the rear focal plane of the lens acquires only a square-law factor as a result of longitudinal displacement of the object. Thus, longitudinal displacement can be compensated by registration of the field in the focal plane. Figures 3, references 8: 3 Russian, 5 Western.  
[144-6610]

UDC 535.417.1

#### DIFFRACTION EFFICIENCY OF VOLUME PHASE MICROHOLOGRAMS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 24 Nov 81) pp 490-494

YAKIMOVICH, A.P.

[Abstract] The author considers the diffraction efficiency of holograms formed by beams with aperture comparable with the thickness of the photographic medium. A detailed examination is made of recording of microholograms when the region of intersection of the beams lies completely within the photosensitive layer, and in the case of coincidence of the cross sections of the beams at interception by the input plane of the hologram. The analysis is based on holograms formed by beams with rectangular aperture. For such beams, all cross sections of the hologram are identical, and it suffices to consider the two-dimensional case for determination of diffraction efficiency. It is also assumed that the signal beam, like the reference beam, consists of a single plane-parallel wave, that the photographic material is non-absorbing, and that the permittivity is modulated in the volume of the photographic medium in the region of beam intersection after recording holograms in accordance with the law  $\epsilon = \bar{\epsilon} + \epsilon_1 \cos(\vec{K}\vec{r})$ , where  $\vec{K} = \vec{k}_s - \vec{k}_r$ ,  $\vec{k}_s$ ,  $\vec{k}_r$  are the wave vectors of the signal and reference waves. It is shown that in contrast to the case of holograms of unbounded waves, the diffraction efficiency of microholograms oscillates with increasing amplitude of modulation of the hologram, approaching some limiting value that depends on the form of hologram, and lies between 0.5 and 1. It is also shown that images of information transparencies reconstructed from microholograms will be nonuniform in intensity. Figures 3, references 3: 1 Russian, 2 Western.  
[144-6610]

## QUALITY OF SYSTEM THAT PRODUCES THREE-DIMENSIONAL RASTER-HOLOGRAPHIC IMAGE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 15 Dec 81) pp 495-500

GAL'PERN, A.D., DENISYUK, Yu.N. and ROZHKOV, B.K.

[Abstract] In cases where direct holography involves technical difficulties, three-dimensional images of extended objects can be produced by first using a raster system to record the image in white light, and then converting the image to a hologram. This technique necessitates high density of recording the stored information. One way to increase recording density is holographic recording of the spectrum of the aspectogram (the aggregate of micro-images produced in raster photography). The three-dimensional image can be reconstructed by projecting the reconstructed image of the aspectogram in the plane of the transilluminated raster screen. In this paper, an experimental investigation is made of this method of three-dimensional raster-holographic imaging, the resolution in cross sections of the image is determined, and image quality is compared with its raster analog. The optimum position of the image of hologram registration is determined. It is shown that the method yields images of satisfactory quality when holograms are small. Image quality can be further improved by using high-quality optics for Fourier transformation and scattering screens with a certain scattering indicatrix. Figures 5, references 9: 8 Russian, 1 Western.  
[144-6610]

## FREQUENCY TUNING OF FOUR-PHOTON MIXING EMISSION IN BIREFRINGENT FIBER-OPTICS LIGHT GUIDE

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 23,  
12 Dec 83 (manuscript received 14 Jul 83) pp 1455-1459

DIANOV, Ye.M., ZAKHIDOV, E.A. and KARASIK, A.Ya.

[Abstract] Thanks to the possibility of maintaining high power densities on considerable lengths of interaction of radiation with the medium, fiber-optics light guides reduce the power level at which nonlinear optical effects such as stimulated four-photon processes are observed. Phase synchronism in four-photon mixing in a fiber-optics light guide can be achieved by dispersion. When a certain form of dispersion is used, four-photon processes can provide information on the physical parameters associated with this type of dispersion. Previous research by the authors has shown that studying stimulated four-photon processes gives information on the physical characteristics of fiber-optics light guides. In a birefringent single-mode fiber-optics light guide there is a difference between the indices of refraction along the two principal axes, resulting in different constants of propagation of waves with orthogonal polarizations coinciding with these axes. Thus, if pumping in the light guide propagates with polarization coincident with the

slow axis, while the Stokes-anti-Stokes components of four-photon processes coincide with polarization along the fast axis, phase synchronism will occur on a certain frequency depending on birefringence. This hypothesis was investigated in a light guide with parameters such that it was single-mode over the entire tuning range of pumping, and the characteristic parameter was in a region where changes in birefringence due to ellipticity of the core could be disregarded. Pumping sources were YAG:Nd and tunable dye lasers. The results show that the difference in constants of propagation between the two principal axes of the light guide is a linear function of emission frequency. Studies of the effect of mechanical stress and pressure on the frequency characteristics of four-photon processes showed that broadening of spectra occurs due to the spectrum of birefringence induced by external pressure. Figures 2, references 9: 4 Russian, 5 Western.  
[117-6610]

UDC 539.56:539.19

# RESONANT MAGNETIC ROTATION OF POLARIZATION OF LASER EMISSION BY SURFACE-ADSORBED $\text{Br}_2$ MOLECULES

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 27 Jun 83) pp 7-10

BARAULYA, V.I., BETEROV, I.M., DMITRIYEVA, N.I. and CHEBOTAYEV, V.P.

[Abstract] A report on experimental observation of the effect of resonant magnetic rotation of polarization of laser radiation by molecules adsorbed on a solid surface. This effect could be used as the basis for a new method of studying surfaces. Linearly polarized laser emission is incident through a polarization filter on a reflective surface coated with adsorbed particles precipitated from the gas phase. The reflected radiation passes through a crossed polaroid (analyzer) and is incident on a photocell. The specimen is placed in a longitudinal magnetic field. A signal appears on the photocell when the plane of polarization of the laser emission is rotated upon double passage through the adsorbed layer. The rotation of polarization can be observed in a reflective arrangement because the direction of rotation is associated with the direction of the vector of magnetic field strength, and is independent of the direction of propagation of light. The material chosen for experimental study was molecular bromine adsorbed on the surface of germanium at low temperatures. The lasers were helium-neon ( $\lambda = 632 \text{ nm}$ ), argon ( $\lambda = 514.5 \text{ nm}$ ), helium-cadmium ( $\lambda = 441.6 \text{ nm}$ ) and a cw dye laser ( $\lambda = 570\text{--}610 \text{ nm}$ ). The light was passed through a polarization filter and Faraday modulator ( $f = 1.9 \text{ kHz}$ ) and was incident on a quartz vacuum cell with the reflective surface in a longitudinal magnetic field. The reflected radiation was passed through a crossed polaroid and was incident on the photocathode of an FEU-15 photomultiplier. The first harmonic of the signal was amplified and registered on a synchronous detector. The system was calibrated and the sign of the angle of turn was determined by measuring the Faraday rotation in quartz. Accuracy of measurement of the angle of turn was at least  $2 \cdot 10^{-6} \text{ rad}$ . It was found that the Verdet constant is four orders of magnitude higher than in quartz, proving resonant rotation. It is suggested that observation of resonant magnetic rotation could give the pattern of the

spectrum with different numbers of molecular layers in a film, enabling observation of the transformation of the discrete spectrum upon transition from a layer of surface-adsorbed particles to the body of a crystal. When used with other molecules, such as  $O_2$ , this effect could be the basis of a new optical method of studying surface states and checking for surface contaminants. Figures 2, references 9: 8 Russian, 1 Western [145-6610]

UDC 535.2

#### TIME CHARACTERISTICS OF LIGHT WAVE LEVEL IN FLUCTUATING WIND

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 25 Jan 82) pp 41-47

MONASTYRNYI, Ye.A., PATRUSHEV, G.Ya. and POKASOV, V.V.

[Abstract] An examination is made of time characteristics of radiation propagating in a turbulent atmosphere. An expression is derived for autocorrelation functions of amplitude fluctuations of a gaussian beam, and the time spectra of fluctuations in the logarithm of the amplitude are calculated in the first approximation of the method of smooth perturbations, using the hypothesis of "local frozenness" of turbulence, considering only transverse motion of inhomogeneities of the index of refraction. It is shown that when effective perpendicular transport velocity is introduced, all variations of time characteristics that are associated with fluctuations in wind speed and direction are to be found between the two limiting cases of absence of either a fluctuational or regular velocity component. A comparison is made between variations of the time spectra of fluctuations of a plane wave, a spherical wave and a collimated beam under the influence of the fluctuational component of wind speed, and an examination is made of the effect that the internal scale of turbulence has on the time spectra. Figures 4, references 14: 13 Russian, 1 Western. [145-6610]

UDC 535.23:547.97

#### NATURE AND PROPERTIES OF SHORT-WAVE LUMINESCENCE OF POLYMETHYNE DYES

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 15 Mar 82) pp 66-71

POPECHITS, V.I. and SAMTSOV, M.P.

[Abstract] New data are given on the nature and properties of short-wave luminescence of ethanol solutions of previously unstudied polymethyne dyes: 4-{3-[1-methyl-2-(p-methoxyphenyl)-4(1p)benzo [f] quinolinimidene]-1-propen-1-yl}-1-methyl-2-(p-methoxyphenyl)benzo[f]quinolinium iodide (dye I) and 4-{3-[3-ethyl-2-benzo-thiazolylimidene]-1-propen-1-yl}-2-phenyl-1-methylbenzo

[f] quinolinium iodide (dye II), and also 3,3'-diethylthiacarbocyanine with substituents in positions 5,5', 6,6' and 10 (dye III), which has been previously studied (Ye.N. Kaliteyevskaya and T.K. Razumova, OPTIKA I SPEKTROSKOPIYA, Vol 48, No 3, 1980, p 490). The ethanol was thoroughly dehydrated before preparing the solutions. Concentration of the investigated solutions did not exceed  $10^{-5}$  M. Spectral-luminescence and polarization measurements were done on a FLUOROLOG spectrophotometer. The specimens were photostimulated by a DKSSh-1000 lamp through an OS-11 light filter and a layer of water 15 cm thick in the long-wave absorption band of the dyes. The results show that short-wave luminescence of these polymethyne dye solutions with Stokes excitation is due to fluorescence of the photoproducts that are formed in the solutions. This effect is apparently rather general, showing up in solutions of many other polymethyne dyes. These photo-products are most likely dye molecules with conjugate chain broken by photo-oxidation. The fluorescence is due to radiative transitions in the system of terms of the end groups of these broken-chain molecules. Figures 4, references 9: 5 Russian, 4 Western. [145-6610]

UDC 535.375+621.373:535

# THEORY OF STIMULATED RAMAN SCATTERING BY POLARITONS IN CUBIC CRYSTALS IN CASE OF PUMPING WITH BROAD ANGULAR SPECTRUM

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 10 Oct 82) pp 78-82

[Dzhotyan, G.P. and MINASYAN, L.L.]

[Abstract] Stimulated Raman scattering by polaritons in cubic crystals is considered for the case of pumping with inhomogeneous wavefront, the complex amplitude of the pumping wave at the input to the medium being represented as a discrete set of angular modes. The problem is solved, and conditions are found for the pumping wave and the nonlinear medium for which the pumping wavefront is reproduced by the wavefronts of the Stokes and polariton waves. Numerical estimates for a zinc sulfide crystal show that the pumping wavefront is reproduced by the Stokes and polariton wavefronts at pumping intensities in a range of  $10^8$ - $10^{10}$  W/cm<sup>2</sup> for weak parametric coupling, and at intensities in a range of  $10^9$ - $10^{12}$  W/cm<sup>2</sup> for strong parametric coupling of the Stokes and polariton waves when the angular divergence of pumping is  $10^{-3}$ - $10^{-2}$  rad at a pumping frequency of  $4 \cdot 10^6$  GHz and polariton wave frequency of  $5.7 \cdot 10^4$  GHz with transverse relaxation time of  $10^{-12}$  s and coefficient of linear nonresonant absorption of 35 cm<sup>-1</sup>. References 12: 10 Russian, 2 Western. [145-6610]



## INFLUENCE OF DIMENSIONAL QUANTIZATION ON OPTICAL PROPERTIES OF THIN METAL FILMS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 25 Dec 81) pp 97-102

GERKHARDTS, R., KONDRAT'YEV, A.S., KUCHMA, A.Ye, and FORSTMANN, F.

[Abstract] The usual model for analyzing optical properties of thin metal films is a free electron gas with density assumed constant with respect to film thickness and equal to the value in a bulk specimen. However, when films are less than a certain thickness, the finiteness of the transverse dimension of the specimen leads to quantization of carrier motion, which influences a number of physical properties, especially in the occurrence of new branches in the spectrum of collective excitations of the electronic system. In optical properties, quasidiscreteness of the electronic energy spectrum due to dimensional quantization may show up as a change in position of transmission bands, a change of amplitude ratios between reflected and transmitted waves, as well as their polarization, the effect of electroreflection of light and so on. In this paper, the authors study the question of the influence that dimensional quantization has on normal modes of plasma oscillations of the electronic system that are present in films even in the model of a spatially uniform electron gas layer. Analysis shows that although dimensional quantization results in considerable restructuring of the spectrum of collective excitations of the electronic system of thin films, there are no noticeable changes in the law of dispersion for branches of oscillations that exist in the classical approximation, despite a radical change in the structure of conductivity in the direction across the film. Thus in the low-frequency region dimensional quantization has almost no effect on the position of singularities of wave reflection and transmission coefficients. At the same time, a change in transverse conductivity will have an effect on the amplitude ratios between reflected and transmitted waves. Calculation of these relations is a problem of independent interest. Figure 1, references 11: 6 Russian, 5 Western.  
[145-6610]

INTERNAL FIELD OF WATER DROPLET ON LASER EMISSION WAVELENGTHS IN 3.39-10.6  $\mu\text{m}$  BAND

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 30 Dec 81) pp 128-131

LOSKUTOV, V.S. and STRELKOV, G.M.

[Abstract] Previous research on the mechanism of explosive vaporization of water droplets has shown that weakly absorbing droplets exposed to laser pulses in the 0.60-2.36  $\mu\text{m}$  band are vaporized by rapid growth of vapor bubbles



in the vicinity of maxima of the internal field (thermal explosion). The authors consider a similar mechanism on longer wavelengths in the infrared range, where intense sources of laser emission are available, and the coefficient of absorption of water is several orders of magnitude greater. Research data are given on the internal field in water droplets on laser emission wavelengths in the range of 3.39-10.6  $\mu\text{m}$  right up to diffraction values of the order of 900. The purpose of the research was primarily to study the conditions of formation of the maxima of the internal field and their disappearance with consolidation of droplets. Diffraction of electromagnetic waves by a sphere is described by series of associated Legendre polynomials and complex-valued spherical Bessel functions of the first and second kinds of variable index of Mie series. The intensity distribution of the internal field over the volume of the droplet was found to be the same for wavelengths from 3.39 to 5.3  $\mu\text{m}$ . The intensity of the internal field was less than that of the incident radiation nearly throughout the volume of the droplet. Intensification of the internal field over the external field occurs in small regions of the droplet adjacent to the unexposed hemisphere in the vicinity of the principal diameter, and is greatest on this diameter. In an absorbing droplet, the height of the maxima is determined by the resultant of two competing effects: focusing of the part of the energy falling to the cross section of the droplet at individual points of the principal diameter, and Bouguer attenuation in the volume of the droplet. The height of these maxima may change appreciably even with a slight change in wavelength. On a wavelength of 10.6  $\mu\text{m}$ , the effect of Bouguer attenuation predominates in formation of the internal field in consequence of the considerable absorption, and no maxima are observed. In all investigated cases, the internal field is sharply inhomogeneous in absorbing water droplets. Explosive vaporization of an absorbing droplet analogous to that observed in experiments with weakly absorbing droplets may occur over a wide range of radii. Figures 3, references 11: 10 Russian, 1 Western. [145-6610]

UDC 535.42:537.226

# DIFFRACTION OF LIGHT BY DIELECTRIC LAYER WITH SINE-WAVE CORRUGATION OF BOUNDARY. II. DISCUSSION OF SPECIAL SOLUTIONS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 20 Oct 81) pp 140-145

UDOYEV, Yu. P.

[Abstract] The first part of this paper appeared in OPTIKA I SPEKTROSKOPIYA, Vol 55, No 4, 1983, p 713. An examination was made of a method of solving the problem of plane wave diffraction by a dielectric layer with corrugated boundary for two states characterized by the pairs of inequalities

$$k_0 a \ll 1, \lambda_0 / \Lambda < M(n),$$

$$2\pi a / \Lambda \ll 1, \lambda_0 / \Lambda < 1.$$

where  $k_0 = 2\pi/\lambda_0$ ,  $\lambda_0$  is the working wavelength in vacuum,  $M(n)$  is the greater of the quantities  $n_1 + n_3$ ,  $2n_3$ , and the boundary is described by the equation  $y_b = a \cos(2\pi x/\Lambda)$ . Using the approach developed in the first paper, the author derives analytical expressions for the amplitudes of diffracted waves of first order in the initial approximation of the method of successive approximations with consideration of terms no higher than the first order with respect to  $k_0 n$ . It is shown that multibeam interference due to repeated reflections of the primary and diffracted waves on the boundaries of the layer may considerably alter the diffraction properties characteristic of the corrugated interface between semi-infinite media. The results also demonstrate the feasibility of stimulating undamped diffracted waves when a damped primary wave interacts with the corrugation, and transformation of damped diffracted waves to undamped waves. Figures 3, references 6 Russian. [145-6610]

UDC 621.372.8:535

# CALCULATING RADIATION FROM CONVERGING EDGE OF PLANAR OPTICAL WAVEGUIDE. GEOMETRIC OPTICS APPROXIMATION

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 16 Mar 82) pp 155-159

YESKIN, K.F., GRISHMANOVSKIY, A.N. and MAGDINA, I.I.

[Abstract] One of the simplest ways to couple a thin-film waveguide to an optical fiber is through the convergent edge of a planar waveguide. This paper proposes a geometric-optics model for calculating emission from such a coupling element in which the rays propagating in a zigzag path in the waveguide are treated as physical objects that have a certain region of localization, i.e., a finite thickness, rather than as mathematically infinitesimal lines. With a continuous change in properties of the medium, the thickness of a ray is determined by its Fresnel volume. In such a geometric-optics treatment, we pass from the ray construction of images to approximate description of wave fields. Here the Fermat principle is considered as the result of interference of secondary waves generated by the primary wavefront and reaching the observation point along all possible virtual trajectories. In consequence of interference, the field at the observation point is determined by some nearest vicinity of the direct ray, mainly by the first Fresnel zone. Thus, the region of space that forms the field at the observation point is assumed to be finite, whereas in the purely ray approach it is infinitesimal. In the case of waveguide propagation of light for a plane wave in a homogeneous medium, the total Fresnel volume can be broken down into individual regions bounded by a single zigzag ray, taking  $z \approx 2h/\cos \phi$ , where  $h$  is the thickness of the waveguide, and  $\phi$  is the angle of incidence inside the zigzags,  $z$  being taken as the coordinate along the direction of propagation of a ray reckoned from the plane where the field distribution is assumed as given. Here the distribution of intensity of rays reflected from the film-substrate interface can be determined from the intensity distribution on the preceding reflection. The results of calculations by the proposed model are compared with theoretical

and experimental data of various authors. It is suggested that the proposed model should be used for simple engineering calculations of elements for coupling thin-film waveguides to optical fibers through the converging edge of a planar waveguide, if the conditions of applicability of geometric optics are met, and the thickness of the waveguide satisfies the condition of mode propagation close to the cutoff. In designing such elements, consideration must be taken of the divergence of radiation due to finiteness of the distance between input and output. Figures 3, references 8: 6 Russian, 2 Western.  
[145-6610]

UDC 535.36

#### MONOCHROMATIC POINT SCATTERING FUNCTION OF KINOFORM OBJECTIVE LENS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 20 Jan 82) pp 160-166

LEVIN, V.Ya. and SOSKIN, S.I.

[Abstract] An objective lens that includes kinoform surfaces along with refracting surfaces gives rather good aberrational characteristics, since spherical aberration of the derivative of the lens system can be corrected by assigning the appropriate relief structure of the kinoform surface. However, in consequence of the approximation of the aberrational wavefront of the lens system by a limited number of phase levels, the wave aberrations cannot be completely corrected by a kinoform objective. This distorts the point scattering function as compared with the classical aberration-free objective. The authors consider the structure of a monochromatic point scattering function for the center of the field of view of a kinoform objective that includes one kinoform surface with an arbitrary number of phase quantization levels. Such quantization produces nonworking diffraction orders of background images with brightness that decreases with an increase in the number  $M$  of quantization levels. As applied to the kinoform relief, an increase in  $M$  reduces the width of the relief steps, complicating the manufacturing technique. The point scattering function is considered for an objective lens that consists of a lens system and an  $M$ -level kinoform surface that corrects spherical aberration of the system on the working wavelength. Analytical expressions are found for the structure of the point scattering function, and experimental results are given. It is shown that a kinoform objective with stepwise profile is of sufficiently high quality with respect to the overall background for comparatively small  $M$ . Figures 4, references 7: 5 Russian, 2 Western.  
[145-6610]

UDC 522.2.535.317.1

METHOD OF RECONSTRUCTING TWO-DIMENSIONAL AND MULTIDIMENSIONAL IMAGES FROM  
PHASE OF THEIR FOURIER SPECTRUM

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE  
I TEKHNIЧЕСKIYE NAUKI in Russian No 10, Oct 83 (manuscript received 18 Oct 82)  
pp 43-45

BRUK, Yu.M. and SODIN, L.G., Department of Radio Astronomy, Institute of Radio  
Physics and Electronics, UkSSR Academy of Sciences, Kharkov

[Abstract] A method had been proposed for reconstructing images from the  
phase of their Fourier spectrum, namely by representing the image as a  
discrete array of equidistant readouts with the phase of its discrete Fourier  
transform assumed to be given. The problem reduces to a system of linear  
trigonometric equations relating the sought readouts to that known phase only.  
For a two-dimensional image defined on an  $N \times N$  grid this system of equations  
has  $N^2 - 1$  unknowns. The two-dimensional problem can be reduced to a series of  
one-dimensional ones, namely reconstruction not of the two-dimensional image  
but of real and imaginary parts of the spectrum of its one-dimensional line  
sections (rows or columns). This fundamental transformation yields a system  
of linear trigonometric equations with  $2N - 1$  unknowns depending on only one  
space frequency and thus greatly simplifies the solution. The coefficients  
of these unknowns, as well as the right-hand sides with this space frequency  
held constant, depend on the other space frequency. This modification of the  
image reconstruction procedure reduces the necessary number of arithmetic  
operations and number of storage cells in the direct-access computer memory  
from  $N^6$  and  $2N^4$  to  $8N^4$  and  $8N^2$  respectively. Addition of approximately  
 $2N^2 \log_2 N$  fast Fourier transformations does not diminish the overall advantages.  
The method can be extended to reconstruction of multidimensional images.  
Article was presented by Academician (UkSSR Academy of Sciences) S.Ya. Braude.  
References 5: 1 Russian, 4 Western.  
[103-2415]

## DOUBLE SCATTERING BACKGROUND IN A CW LIDAR

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian Vol 18, No 5, Sep-Oct 83 (manuscript received 20 Jun 82) pp 291-295

SINYAVSKIY, A.V., Institute of Physics Research of the ArmSSR Academy of Sciences

[Abstract] The equation for lidar probing of a homogeneous medium is written for the case of two-fold scattering in terms of the radiated power, speed of light, the back-scatter coefficient, path attenuation, the one-time scattered signal from the given range, the normalized scattering indicator in the back direction, the scattering coefficient and the angular field of view of the receiver. The solution of this equation is an estimate of the contribution of information contained in a doubly scattered signal from a CW lidar, modulated by a sine wave. An analytical expression is derived for the phase of the received signal and the change in the modulation level with double scattering. The equations are used to plot the phase and modulation level for modulating frequencies of 100 KHz, 1 MHz and 10 MHz as a function of the path attenuation. An expression is also adduced for the ratio of the power of the AC component of a double scattered transmission to the analogous component of a one-time scattered signal. The behavior of this function shows that the doubly scattered signal is greatly dependent on the type of scattering aerosol and thus permits the possibility of identifying an atmospheric aerosol by studying such signals. The author is grateful to R.A. Kazaryan for his attention to the work and discussing the results. Figures 3, references 12: 10 Russian, 2 Western.

[107-8225]

UDC 621.362:537.581

## DEPENDENCE OF EFFICIENCY OF THERMIONIC ENERGY CONVERTER ON OPTICAL PROPERTIES OF ELECTRODES

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 27, No 9, Sep 83 (manuscript received 4 Feb 83) pp 813-816

BULYGA, A.V., Institute of Solid State and Semiconductor Physics, BSSR Academy of Sciences

[Abstract] An analytical relation is established between the efficiency of a thermionic energy converter and the photoemission characteristics of its electrodes, emitter and collector, those characteristics depending on the optical properties and particularly the photoemissivity of the electrode surfaces. The incident radiant flux is assumed to have a continuous spectrum and to consist only of photons with  $h\nu \geq h\nu_0$  above the red edge, the energy of the photoelectric effect at that edge being determined by the work function of the emitter according to the Richardson-Dushman equation. Further calculations

based on this equation, assuming a nearly perfect emissivity of the electrode surface, reveal an anomalously strong temperature dependence of the work function and its effect on the mechanism of thermionic energy conversion. The results indicate how irradiation of the collector by the emitter decreases the conversion efficiency. Simple expressions are derived for the interelectrode potential difference and for the efficiency of an ideal diode operating as energy converter. Article was presented by Academician (BSSR Academy of Sciences) B.B. Boyko. Table 3, references 8 Russian. [88-2415]

UDC 621.373.826

#### PHASE METHODS OF CONTROLLING SPECTRUM OF GENERATED RADIATION

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 27, No 9, Sep 83  
(manuscript received 31 Jan 83) pp 798-800

VOYTOVICH, A.P., Institute of Physics, BSSR Academy of Sciences

[Abstract] All known methods of frequency selection for controlling the spectrum of generated radiation are based on an amplitude criterion for oscillation. Here the feasibility of controlling the spectrum on the basis of a phase criterion is considered, and is demonstrated on a continuous-wave ring laser. A small portion of the resonator is occupied by an element with the optical length of path for a generated wave  $L_1 = n_1 l_1$  ( $l_1$  - geometrical length of element,  $n_1$  - refractive index of medium). The lifetime of a photon in the resonator and thus the mode width as well as the rate of change of its phase, without and with emission respectively, are related to the energy loss per pass around the resonator. Figure 1, references 7 Russian. [88-2415]

UDC 535.012.2

#### EFFECT OF AMPLITUDINAL ANISOTROPY ON POLARIZATION CONTROL OF LASER RADIATION

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 4, Oct 83  
(manuscript received 20 Nov 81) pp 670-672

DEM'YANTSEVA, S.D., LAZAREV, G.A. and TABARIN, V.A.

[Abstract] Magneto-optical control of laser beam polarization under conditions of amplitudinal anisotropy in the resonator is analyzed theoretically for two practical modes of producing and varying the anisotropy. The first method, based on the Faraday effect, involves using a quartz plate and rotating it relative to the optical axis of the resonator as partial polarizer. This varies both transmission coefficients  $k_1$  and  $k_2$  characterizing, respectively, maximum and minimum principal transmission through the polarizer. The second method involves using Brewster windows in the resonator. In this case only the coefficient  $k_2$  (minimum transmission) decreases, while the coefficient  $k_1$

(maximum transmission) remains constant, as the number of Brewster windows is increased. The results of numerical calculations were verified experimentally. Measurements with a  $\text{Y}_3\text{Fe}_5\text{O}_{12}$  single crystal controlling the linear polarization of an He-Ne laser beam ( $\lambda = 3.39 \mu\text{m}$ ) have confirmed that the efficiency of polarization control increases with decreasing anisotropy. Figure 1, references 5: 2 Russian, 3 Western.  
[29-2415]

UDC 535.317.1

#### HOLOGRAPHIC LENS FOR OPTICAL CORRELATOR

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 55, No 5, Nov 83  
(manuscript received 15 Mar 82) pp 945-949

SEMENOV, G.B., KORESHEV, S.N., PAVLOV, A.V. and SHUBNIKOV, Ye.I.

[Abstract] Based on analysis of aberrations of holographic lenses, the authors demonstrate the feasibility of making an off-axis lens for correlation analysis of images with aberrations analogous to an in-line lens. The paper gives the results of measurement of the quality of the wavefront formed by such a lens and results of testing the lens in an optical correlator. Calculation of the holographic lens was based on the requirement that wave aberrations of the lens not exceed a quarter wavelength. It is shown that for small values of spatial frequencies to be processed in the correlator when the input transparency is parallel to the plane of the holographic lens, the difference in sines of the angular coordinates of the sources does not depend on the carrier of the spatial frequency of the holographic lens. Conditions are determined for recording a holographic lens enabling processing of signals with spatial frequencies to  $15 \text{ mm}^{-1}$ . Experiments are done to determine the way that wave aberration of the holographic lens depends on the spatial frequency of the signal being processed. Test results of the lens in an optical correlator arrangement show that invariance to displacement of the input image deteriorates with an increase in working spatial frequencies. However, the lens did operate satisfactorily in the calculated frequency range, and variation of the correlation signal was slight over the field. Figures 5, references 6: 2 Russian, 4 Western.  
[111-6610]

#### GUNN-DOMAIN DOPPLER EFFECT

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 23,  
12 Dec 83 (manuscript received 12 Jul 83) pp 1416-1418

SANDOMIRSKIY, V.B. and SHEVEREV, A.V.

[Abstract] When a Gunn domain propagates in a semiconductor, electro-optical effects should produce differences in the index of refraction of the domain and in the region outside of it. Thus the Gunn domain can be treated as a mirror moving at a velocity of  $10^7 \text{ cm/s}$  or more. Consequently, the Doppler



effect should shift the frequency of light reflected by such a mirror relative to the frequency of the incident light. In addition, as a result of absorption of light in the semiconductor combined with processes of generation and disappearance of the domain, the light reflected from the domain will be modulated in intensity with the Gunn-diode oscillation frequency as it leaves the specimen. The authors analyze this effect for GaAs and InP, deriving expressions for the coefficient of reflection and frequency shift. References 4: 2 Russian, 2 Western.  
[117-6610]

#### LIGHT EMISSION OF DIELECTRIC UNDER EFFECT OF RAPIDLY ALTERNATING FIELD

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 23,  
12 Dec 83 (manuscript received 19 Aug 83) pp 1452-1455

CHERNYSHEV, V.V.

[Abstract] Previous research on the effect of light emission by ferroelectrics has stressed emission of light by the ferroelectric itself with a change in polarization, i.e., the relation between the electronic subsystem and spontaneous polarization. In this paper the author considers light emission in a dielectric that is in contact with a ferroelectric at the instant when reorientation of domains occurs. The ferroelectric specimens were opaque barium titanate disks 10 mm in diameter and 2 mm thick. A sine-wave switching voltage on a frequency of 50 Hz was applied to electrodes on the disks. Part of the lateral surface of the disk was polished to a flat, to which the dielectric was applied. In studies on liquid dielectrics, the ferroelectric was immersed in a glass cell containing the liquid. Emission was recorded by a photomultiplier. The solid dielectrics studied were thin films of silicon dioxide and aluminum oxide. Liquids were water, glycerin, ethanol, and isopropyl alcohol. Curves are given showing photocurrent as a function of the amplitude of the repolarizing electric field. Figures 2, references 5: 3 Russian, 1 Polish, 1 Western.  
[117-6610]

#### INFLUENCE THAT DIFFUSION MOTION OF ATOMS HAS ON DOUBLE RADIO-OPTIC RESONANCE SIGNAL SHAPE

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 24,  
26 Dec 83 (manuscript received 28 Jun 83) pp 1479-1483

GORNYI, M.B., MARKMAN, D.L. and MATISOV, B.G., Leningrad Polytechnical  
Institute imeni M.I. Kalinin

[Abstract] When the buffer gas pressure is low (of the order of 1 mm Hg) or the gas cell is small, the main contribution to broadening of the double radio-optic signal is from interaction between the working atoms and the cell wall. As of now, there has been no systematic theoretical treatment of this problem. In this paper the authors study the influence of diffusion motion of atoms on signal shape and broadening. The analysis is based on the exact



solution of the system of kinetic equations for elements of the density matrix of working atoms. The initial model is a gas cell filled with a mixture of working (alkaline) atoms and buffer atoms or molecules. Three-level working atoms are assumed, levels 1 and 2 being hyperfine sublevels of the ground state, while level 3 is the optical level. Optical pumping is from the first sublevel only, and a radiofrequency field is applied to transition 1-2. Analysis of the expression for the double radio-optic resonance signal in the case of a spherical cell shows that signal shape is non-lorentzian, although described by a symmetric power law. In the general case where the optical pumping rate and rf field are non-zero, signal broadening due to collisions of atoms with cell walls depends on the intensity of optical and rf radiation. This means that diffusion flows of oriented atoms contribute to broadening. Figures 4, references 3 Russian. [114-6610]

#### PROFILING RADIATION INTENSITY WITH PHASE CONTROL

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОЙ ФИЗИКИ in Russian Vol 9, No 24, 26 Dec 83 (manuscript received 24 May 83) pp 1531-1534

ROZANOV, N.N. and SEMENOV, V.Ye.

[Abstract] Tailoring a gaussian laser beam for supergaussian intensity profile by transmission through an anodizing diaphragm involves considerable energy losses. Intracavity control by mirrors with profiled cross section introduces changes in the mode composition of lasing. In this paper, the authors consider the possibility of intensity profiling with phase control by a flexible mirror. It is shown that any amplitude-phase distribution can be produced, including phase-conjugate reflection of a given wave, by using two flexible mirrors: one to shape a given amplitude intensity profile, and the other for phase control. Algorithms of mirror bending by direct optimization and iteration methods are considered. Figures 2, references 6: 5 Russian, 1 Western. [114-6610]

UDC 535.317.1

#### OPTIMUM LINEAR FILTRATION OF IMAGES

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84 (manuscript received 24 May 82) pp 175-178

STOLYAROV, Yu.V.

[Abstract] Recent experimental research on optimum filtration by both optical and computer techniques has shown that image quality can be improved; however, results have been rather disappointing. On the other hand, theoretical estimates of filtration effectiveness predict considerably better results. In addition to various imperfections in the filter and processing system, the influence of quantization and discretization noises of the image at computer input and the like, ineffective filtration is due to imperfections of processing algorithms, a considerable number of assumptions

and simplifications relative to the real image and the characteristics of the output system that do not correspond to the actual situation. It is suggested that the most serious errors are to be found in assumptions that:

1. photographic film granularity noises are additive; 2. the noise spectrum is constant, or granularity is represented by white noise statistically independent of the signal; 3. there are no inherent noises in the optical output and processing system, no inherent filter noises or image quantization and discretization noises; 4. noises of the signal and of the processes of extraction and filtration are gaussian; 5. the criterion of minimum standard deviation is correct in the Wiener algorithm. The author proposes a linear filtration algorithm that is optimum for assumptions 1-3 and 5. Comparison of the results of filtration by the proposed optimum method with the results of the inverse and Wiener methods shows considerable image improvement with the proposed algorithm. Starting with a width of vertical elements of letters in the image of printed text equal to  $146\text{ }\mu\text{m}$ , inverse filtration reduces the width to  $57\text{ }\mu\text{m}$ , Wiener filtration--to  $50\text{ }\mu\text{m}$ , and the proposed optimum algorithm reduces the width of vertical elements to  $37\text{ }\mu\text{m}$ . Although the resultant photographic image has a somewhat higher noise level, this is not detrimental to legibility. Figure 1, references 9: 5 Russian, 4 Western.

[145-6610]

UDC 535.317.1

#### PROPERTIES OF REFLECTIVE ELEMENTS IN OPTICALLY COHERENT IMAGE PROCESSING SYSTEMS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 56, No 1, Jan 84  
(manuscript received 10 Dec 82) pp 190-192

DUDKINA, Ye. A. and DUDKIN, K.I.

[Abstract] The authors analyze the capabilities of concave and convex spherical, elliptical and hyperbolic mirrors as transforming components of specialized optical processors. It is shown that the distribution of complex amplitudes in the rear focal plane of a reflective spheroid is related to the phase transfer function of the transparency by a Fourier transform differing from the exact Fourier transform in the presence of a phase factor preceding the integral, a phase factor in the integrand, a weighting factor with the function being transformed, and a scale factor in the Fourier kernel. These factors can be reduced by proper choice of relative placement of the planes of the transparency and spectrum relative to the mirror. The distribution of complex amplitudes in the rear focal plane is similar for the other second-order mirror surfaces, the ellipsoid and hyperboloid. Because the dimensions of the working regions in the object and spectrum planes of real optical processors considerably exceed the paraxial dimensions, field aberrations arise. Therefore the next stage in development of an optical processor with reflective Fourier components is to choose a compensator with transfer function that would modify the distribution of complex amplitudes in the plane of the spectra to minimize both the errors of the ideal optical Fourier transform and the errors caused by field aberrations of the system. Figure 1, references 4 Western.

[145-6610]

RESONANCE AND EDGE AMPLIFICATION OF AN ELECTRIC FIELD IN A PLASMA RESONANCE LAYER AND ACCELERATION OF PARTICLES AT PLASMA INHOMOGENEITIES

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 20, 26 Oct 83 (manuscript received 20 Jun 83) pp 1243-1247

ASKAR'YAN, G.A. and BULANOV, S.V., Physics Institute imeni P.N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Field amplification and the acceleration of particles transiting a flat plasma layer in an external sinusoidal electric field in the plasma resonance range are possible, where the electric field has a component perpendicular to the plasma surface. The field intensity in the resonance layer is sharply increased under certain conditions. The energy of the charged particles passing through the resonance layer can rise. This paper notes the possibility of such phenomena at the vertices of sharp points (elongated plasma inhomogeneities) due to point amplification of the field, polarization resonance as well as antenna resonance. The conditions for these three effects are discussed theoretically without adducing any experimental data or sample calculations. It is noted that the amplification of an edge field leads to the intensification of the field in the purely plasma resonance region located in the edge area of the concentration gradient decline. Such field amplification and particle acceleration can be utilized not only to boost the energies of accelerated particles, but also for high efficiency microwave voltage and current generators and streamer particle acceleration. Figure 1, references 11: 9 Russian, 2 Western.  
[16-8225]

OSCILLATIONS IN A PLASMA LENS AND THEIR INFLUENCE ON A FOCUSED ION BEAM

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 20, 26 Oct 83 (manuscript received 21 Jul 83) pp 1228-1232

GASANOV, I.S. and PROTSENKO, I.M., Institute of Physics of the UkrSSR Academy of Sciences, Kiev

[Abstract] The medium in a plasma lens is an uncompensated plasma with an excess electron space charge. The electron cloud rotating in the radial electric field and the magnetic field crossing it, where the cloud has a nonmonotonic radial density profile, is not stable in terms of the development

of so-called "diokotron" oscillations at a frequency close to  $\omega = cEm/rH$ , where  $m$  is the azimuthal mode number and  $r$  is the radius. Elevating the gas pressure in the region of the lens boosts the slow ion concentration. Ion motion in the crossed fields is not drift motion; in contrast to the electrons, ions experience radial oscillations in the potential well of the uncompensated electron space charge. Under certain conditions, the coupling of these oscillations to the slow azimuthal diokotron waves can excite the electron-ion instability system. Theoretical analysis shows that the development of an instability is possible at frequencies less than the angular rotation frequency of the electron cloud. Analysis also indicates that the electron-ion instability exhibits a threshold behavior with respect to the concentration of slow ions and the electric and magnetic field intensities. These and other theoretical findings were checked experimentally using the facility described in PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 3, 1977, p 1153 by M.D. Gabovich, et al. A pulsed or steady-state He ion beam at a current of up to 50 or 20 mA respectively with energies up to 35 KeV was passed through a small aperture, short plasma lens. At nitrogen pressures less than  $2 \cdot 10^{-5}$  mm Hg, oscillations between 5 and 45 MHz occur both in the lens itself and the ion beam; the frequency is proportional to the voltage across the lens and declines with an increase in the magnetic field. It is demonstrated that: 1) Electron-electron "diokotron" instability is excited in such a lens in a wide pressure range; 2) A lower frequency electron-ion instability is excited in the lens at a particular concentration of slow ions; 3) The excitation of electron-ion oscillations is accompanied by significant density modulation and a high overall ion beam current; 4) It is possible to select the lens parameters which make it effective without exciting the most intense electron-ion instability. The authors would like to thank M.D. Gabovich for his constant interest in the work. Figures 2, references 7: 5 Russian, 2 Western.

[16-8225]

UDC 533.9.082.5

#### CHANNELED HELICON WAVES IN MAGNETIZED SOLID-STATE PLASMA

Tomsk IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: FIZIKA in Russian Vol 27, No 1, Jan 84 (manuscript received 7 Jun 83) pp 102-103

YANKAUSKAS, Z.K., Vilnius Institute of Structural Engineering

[Abstract] It is demonstrated theoretically that a quasi-parallel beam of electromagnetic radiation can be propagated almost losslessly over short distances, when the aperture is much larger than the wavelength. The proof is based on the equations describing helicon waves in an electromagnetic field. The resulting wave equation reduces to a parabolic one which describes a slightly diverging Gaussian beam. This equation is solved for the fundamental radially symmetric mode. A method has been proposed and almost completely developed for experimental verification by exciting and recording channeled electromagnetic waves in a solid-state plasma. References 4 Russian.

[95-2415]

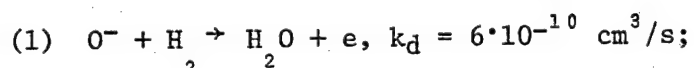
# INFLUENCE THAT PROCESSES OF ELECTRON DETACHMENT FROM NEGATIVE IONS HAVE ON MECHANISM OF CURRENT FLOW IN MEDIUM-PRESSURE GLOW DISCHARGE

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian  
Vol 142, No 6, Nov-Dec 83 (manuscript received 14 Oct 82) pp 25-31

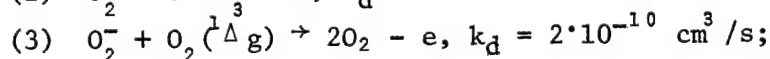
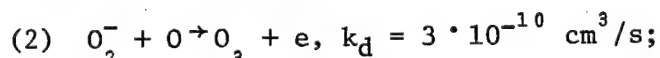
BREYEV, V.V., DVURECHENSKIY, S.V. and PASHKIN, S.V., Troitsk

[Abstract] The problem of the part played by electron detachment from negative ions in a medium-pressure glow discharge is important for studying the mechanism of flow of electric current and for describing energy balance and discharge instability. While there is considerable experimental evidence that processes of detachment are significant in the mechanism of current flow, the question of how these processes might influence specific discharge characteristics remains open in large measure. The authors divide such processes into three groups:

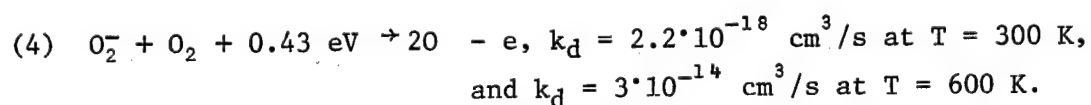
a. detachment of an electron accompanying associative processes of collision between negative ions and molecules, e.g.



b. detachment of an electron accompanying collisions of negative ions with metastable particles in concentrations that increase with increased energy input into the discharge, e.g.



c. detachment of an electron accompanying collisions of negative ions with molecules due to high inherent kinetic energy of ions that is accumulated in the electric field of the discharge, e.g.



A detailed investigation is made of the influence that detachment of type (1) has on the anode region of the discharge, as well as the effect of process (4) on parameters of the positive column and the anode region. The mechanism of current flow is analyzed without assuming quasineutrality of the plasma, thereby taking the anode region into consideration. It is found that detachment of type (1) causes a considerable reduction of ion concentration, slightly increases electric field strength in the positive column, and reduces the field in the anode region as compared with absence of detachment. The anode drop in the case of detachment at a constant rate is lower, and the dependence of anode voltage on interelectrode spacing is weaker than in the case of absence of detachment. In case (4), where the rate of detachment is a function of the electric field, there may be a sharp jump in the electric field for large

inter-electrode spacing in the positive discharge without interruption of ion currents. On the cathode side of this jump, the balance of charged particles and the magnitude of the electric field are determined by the balance of rates of attachment and recombination, and ion currents rise from the cathode toward the jump. On the anode side of the jump in the region where electric field intensities are high, the balance of charged particles and electric field strength are determined by detachment and ionization, and ion currents drop from the jump toward the anode. An increase in the amplitude of detachment gives rise to a region of elevated electric fields near the anode that is separated from the remainder of the positive column by an abrupt jump in the field. This may be a factor in the experimentally observed formation of spots and filaments near the anode. Figures 5, references 8 Russian. [134-6610]

#### SOURCE OF RADIATION ON $L_{\alpha}$ WAVELENGTH OF HYDROGEN FOR DIAGNOSING HIGH-TEMPERATURE PLASMA

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 23, 12 Dec 83 (manuscript received 20 Sep 83) pp 1461-1465

VATISHCHE, S.A., BURAKOV, V.S., GLADUSHCHAK, V.I., GURLENYA, V.I., MOSTOVNIKOV, V.A., MOSHKALEV, S.A., RAZDOBARIN, G.T., SEMENOV, V.V., TARASENKO, N.V. and SHREYDER, Ye.Ya.

[Abstract] The paper gives the results of experiments on developing an intense source of radiation on the  $L_{\alpha}$  wavelength of hydrogen by a method of generating the third harmonic of laser emission, and discusses possibilities of using this source for determining the concentration of atomic hydrogen. To increase emission power as compared with previous experiments, laser parameters were improved and long-focus optics were used, enabling operation at high pressures. The experimental facility is described in a previous article [S.A. Vatishche et al., PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, Vol 8, 1982, p 1375]. The new parameters of the facility were: maximum laser power on wavelength of 364.8 nm--- $10^7$  W; pulse duration---20 ns; divergence of laser beam--- $\sim 10^{-4}$ . A light beam 10 mm in diameter was focused on a cell 100 cm long containing a mixture of krypton and argon by a quartz lens with focal length of 100 cm. Radiation on the  $L_{\alpha}$  wavelength was recorded by an open photomultiplier through a set of light filters attenuating the luminous flux by a factor of  $10^5$ . A chamber filled with argon was placed beyond the exit window of the cell to record Rayleigh scattering in the direction perpendicular to propagation of light. Individual mixtures were prepared with ratios of partial pressures of argon to krypton ranging from 2.4 to 2.8. The optimum pressure of each mixture was determined, corresponding to the maximum power of the third harmonic. The power of the mission coupled into the cell ranged from  $10^6$  to  $8 \cdot 10^6$  W. It was found that phase matching can be achieved by a judicious choice of the argon-to-krypton pressure ratio at rather high krypton pressures. Maximum power conversion efficiency of about  $10^{-14}$  was attained when the product of initial power multiplied by krypton pressure was greater than  $(0.5-2) \cdot 10^9$  W·mm Hg. The coefficient of conversion to the third harmonic remained constant with

variation in line-width on the fundamental frequency from  $10^{-1}$  to  $10^{-3}$  nm. Maximum energy attained on the 121.6 nm wavelength was 8  $\mu$ J. Experiments on Rayleigh scattering were done to verify the feasibility of using the proposed source for fluorescence determination of the concentration of atomic hydrogen. The resultant intensity of Rayleigh scattering was equivalent to fluorescent emission of hydrogen atoms in concentrations of  $(1-5) \cdot 10^9 \text{ cm}^{-3}$ . Figures 2, references 7: 2 Russian, 5 Western.

[117-6610]



## LOCALIZED WAVES IN NONHOMOGENEOUS MEDIA

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 142, No 1, Jan 84 pp 61-98

GUREVICH, A.VI. and MINTS, R.G., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] The theory of nonlinear waves in nonhomogeneous media is reviewed, specifically localization and stabilization of nonlinear waves describable by a single equation of the  $\frac{\partial}{\partial t} \mu \frac{\partial}{\partial t} + \nu \frac{\partial}{\partial t} = \frac{\partial}{\partial x} \frac{\partial}{\partial x} - q \frac{\partial}{\partial x} - f(\phi)$  kind where  $\mu, \nu, \chi, q, f$  are generally functions of the variable  $\phi$  (electric field, temperature, concentration of atoms or active centers, atom displacement, phase or modulus of order parameter, modulus of quasi-particle concentration) and of the space coordinate. The review begins with the theory nonlinear quasi-steady waves, after a preliminary analysis of such waves in homogeneous media in the basic forms of domain wall and domain. The review proceeds with such waves in nonhomogeneous media characterized by the parameter  $\epsilon = L/l$ , ratio of the space scale of temperature variation to the dimension of an inhomogeneity. An analytical solution of the localization problem is here possible only for the two extreme cases of  $\epsilon \gg 1$  (point inhomogeneity) and  $\epsilon \ll 1$  (smooth inhomogeneity). A domain and a domain wall are considered in the first case, a domain is considered in the latter case. A model is found for which an exact solution to the problem is attainable, namely an equation with  $\mu = 0$ ,  $f(\phi)$  a piecewise-linear function, and  $\nu, \chi, q$  not depending on  $\phi$ . The problem is solved for localization of a "strong field" domain at a symmetric inhomogeneity, with a subsequent analysis of localization dynamics and stability. The review continues with nonlinear static waves corresponding to an equation where all coefficients are arbitrary functions of  $\phi$ . This case is treated by establishing the statistical distributions, again for a "strong field" domain and for a domain wall, whereupon the corresponding condition for stability under small perturbations  $\delta\phi(x, t)$  is established. The general theory and method of analysis are applied to a few specific situations of interest, namely: localization of resistive domains in superconductors with inhomogeneities and resulting current-voltage characteristics of such super-conductor devices; optical discharge in laser gases with localization of ionization waves or plasma domains; temperature-electric domains in current-carrying normal metals and resulting N-form current-voltage or heat transfer-power characteristics; reaction switch waves on domain walls in a chemical reactor; domain walls in a superconductor coexisting with a resistive phase or in a superconductor

consisting of several superconducting phases with different values of the order parameter, domain walls in such media being associated with diffusion of excess electronic excitations as a result of irradiation with laser power above a threshold level; thermal switch waves as domain walls in devices where dielectric-to-metal transition occurs, usually with attendant temperature or pressure rise accompanying the jump of electrical conductivity and the drastic change in optical properties. The review concludes with dissipative structures containing several inhomogeneities which can give rise to metastable nonhomogeneous states and to localization of either domain walls or domains, such structures including smooth, periodic, random and other ones in physical, chemical, or biological systems. Figures 22, references 144: 108 Russian, 36 Western.  
[96-2415]

UDC 437.874.4

#### SPECTRAL THEORY OF TWO-DIMENSIONAL OPEN RESONATORS WITH DIELECTRIC INCLUSIONS

Kiev DOKLADY NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 1, Jan 84 (manuscript received 3 May 83)  
pp 66-70

POYEDINCHUK, A.Ye., Institute of Radiophysics and Electronics, UkSSR Academy of Sciences, Kharkov

[Abstract] An algorithm is constructed for calculating the spectrum of natural electromagnetic oscillation modes in a two-dimensional open resonator with dielectric inclusion of "regular" shape. As a specific example the author considers a resonator formed by two ideally conducting circular arcs and an inclusion in the form of a circular solid cylinder of a material with complex permittivity and permeability. Each resonator arc is referred to its local polar system of coordinates, with the polar axes of both systems parallel to one another. The problem reduces to the Helmholtz equation and determining the values of its spectral parameter (wave number) for which it has a nontrivial solution, for an E-mode or an H-mode, satisfying the Meixner boundary condition, the conditions of coupling, and the drift condition for radiation which varies harmonically in time. Application of the Riemann-Hilbert method yields an infinite linear system of equations whose matrix elements are meromorphic functions of the spectral parameter. With the aid of two lemmas pertaining to finite-meromorphicity and kernel content of the operator-function of the spectral parameter, and to the set of its eigenvalues in the complex plane, two theorems are proved for this boundary-value problem, its characteristic determinant equation, and its solution. The algorithm of numerical solution by the Newton method and the asymptotic estimate of its convergence rate are based on these theorems and lemmas. Article was presented by Academician (UkSSR Academy of Sciences) V.P. Shestopalov. Figure 1, references 8 Russian.  
[99-2415]

## DIFFRACTION OF ELECTROMAGNETIC WAVES BY GRATING OF OBLIQUE STRIPS

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 1, Jan 84 (manuscript received 21 Dec 82) pp 60-64

VOROB'YEV, S.N., LITVINENKO, L.N., corresponding member, UkSSR Academy of Sciences, and PROSVIRNIN, S.L., Department of Radio Astronomy, Institute of Radio Physics and Electronics, UkSSR Academy of Sciences, Kharkov

[Abstract] The problem of diffraction is solved for a plane H-polarized electromagnetic wave  $H_i = e^{ik(y \sin \varphi - z \cos \varphi)}$  varying harmonically in time and impinging at angle  $\varphi$  on an array of parallel identical infinitesimally thin, infinitely long, and ideally conducting strips. The resulting electromagnetic field is sought as superposition of the incident field and the scattered one. The latter is resolved into a spectrum of plane waves  $H_s^{(+n)} + H_s^{(-n)}$  in the region between every two neighboring strips, each wave represented in the form of an integral. The problem reduces to a system of paired integral equations solvable by the method of residues, with a system of linear algebraic equations of the second kind for the coefficients  $c_n$  of orthogonal functions  $\psi_n$ . Determining the field at slip points requires additional transformations, which are not shown here. Results in the form of dispersion curves are shown for diffraction gratings of the knife-edge type ( $\psi = 0$ ), of the straight type with waveguide region between strips ( $\psi = 90^\circ$ ), and of the oblique type without waveguide region between strips ( $\psi = 75^\circ$ ) ( $\psi$  - slope angle of strips to plane of grating). Figures 2, references 4 Russian. [99-2415]

UDC 517.9+537.533.74

## QUANTUM SCATTERING AND ELECTROMAGNETIC WAVE SCATTERING BY UNBOUNDED OBSTACLES

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA in Russian Vol 16, No 3, Aug 83 (manuscript received 20 Feb 83) pp 80-82

IL'IN, Ye.M.

[Abstract] The author has previously analyzed wave scattering by non-compact obstacles (Il'in, Ye.M., ZAPISKI NAUCHNYKH SEMINAROV LOMI, 1983, Vol 127, pp 68-74) employing first order equations with respect to time (Schrodinger's equation) as well as a second order equation (a wave equation); the wave operators of the latter are applied here to the following three problems: 1) The scattering of electromagnetic waves by a conical obstacle; 2) Plane electromagnetic wave scattering (the p-case), and 3) Three-particle quantum scattering, the hard core model. It is noted in the latter case that there are no substantial impediments to generalizing the results given here to more than three particles. The treatment is purely theoretical, adducing and proving the relevant theorems, without giving sample calculations or references to applications. References 3: 2 Russian, 1 Western. [101-8825]

MULTIPLE WAVE SCATTERING BY INHOMOGENEOUS MEDIUM PERTURBATIONS WHICH ENCOMPASS THE VICINITY OF THE CAUSTIC FOR THE CASE OF OBLIQUE PROPAGATION

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA in Russian Vol 16, No 3, Aug 83 (manuscript received 16 Nov 82) pp 26-31

ZERNOV, N.N.

[Abstract] In contrast to the case of electromagnetic field scattering by perturbations in an inhomogeneous medium which was analyzed assuming that the perturbation was distant from the regions where the regularity of the system of unperturbed field rays was disrupted, this paper considers the situation where the perturbation of the permittivity of the medium takes in the vicinity of the caustic. The author previously simplified this case by treating only the propagation along the gradient of unperturbed properties of the medium, making it possible to write a parabolic equation for the phase. (Zernov, N.N., IZVESTIYA VUZOV. SERIYA RADIOFIZIKA, 1980, No 2, pp 151-158). This is impossible with oblique propagation, so the complete equation must be analyzed. This paper finds the complex phase of the complete field, considering the fact that the unperturbed field in the vicinity of the caustic can be expressed in terms of the appropriate Airy function. The theoretical treatment is applied to a sample case of determining the scattering in the ionosphere at a frequency of 10 MHz. The ionospheric models used permit an analytical solution and equations are given which define the contribution of the region near the caustic to multiple wave scattering. In order to completely describe scattering by a perturbation including the near-caustic region, the entire region occupied by the perturbation must be broken down into this near-caustic region and the region outside of this; the former is described by means of the formula in this paper, while the latter can be found in Zernov's earlier paper above. The expressions derived here can also be used to estimate the contribution of the near-caustic region of an oblique curvilinear caustic. The author is grateful to V.N. Krasil'nikov for his helpful discussion. Figure 1, references 5 Russian. [101-8225]

NONLINEAR DYNAMICS OF RESONANCE-TYPE INSTABILITY IN HIGH-DENSITY ELECTRON BEAM: ANALYTICAL SOLUTION

Tomsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA in Russian Vol 27, No 1, Jan 84 (manuscript received 3 May 83) pp 31-35

KUZELEV, M.V. and PANIN, V.A., Moscow State University imeni M.V. Lomonosov

[Abstract] The problem of instability of a straight high-density electron beam propagating through a slow-wave structure is solved analytically, such a solution being possible because a high density implies a small frequency

deviation of plasma oscillations and thus a resonance mode of instability. The dynamics of this kind of instability and stabilization of resonance are examined from the standpoint of the nonlinearity mechanism, specifically a cubic nonlinearity analogous to that in the case of burst-type instability. First the initial-value or transient problem for the corresponding system of equations of instability evolution is solved, then the more important boundary-value problem. The solution is simple in the ideal case of an adiabatic application of the electric field, in the nonadiabatic real case it is more intricate. The authors thank A.A. Rukhadze for steady interest and for discussion of the results. References 5 Russian. [95-2415]

UDC 517.958:536.71

# EXACT SOLUTIONS TO SYSTEMS OF EQUATIONS DESCRIBING RADIATION TRANSFER WITH DISCONTINUITY AT BOUNDARY BETWEEN TWO MEDIA

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 24, No 1, Jan 84 (manuscript received 29 Dec 81) pp 161-163

ANDREYEV, Ye.S., KOZMANOV, M.Yu. and RACHILOV, Ye.V., Chelyabinsk

[Abstract] The system of four equations of the radiation transfer process at the boundary between two media, one equation for energy  $E_\alpha$  and one equation for intensity  $I_\alpha$  in each medium ( $\alpha = 1, 2$ ), is solved exactly letting  $\sigma T_\alpha^4 = d_\alpha (x + b_\alpha t + e_\alpha)$  ( $T$ - temperature,  $x$ - space coordinate,  $t$ - time,  $\sigma$ - Stefan-Boltzmann constant) and  $I_\alpha = D_\alpha (x + b_\alpha t + e_\alpha) / (g + \mu)$  with absorption included but scattering disregarded. The results obtained for specific values of the constants are compared with those based on the diffusion approximation with the same initial and boundary conditions, for estimating the accuracy of that approximate solution. References 2 Russian. [94-2415]

UDC 519.6:533.7

# NUMERICAL SOLUTION OF EQUATIONS OF THREE-DIMENSIONAL MIXING LAYER

Moscow ZHURNAL VYCHESLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 24, No 1, Jan 84 (manuscript received 9 Sep 81, after revision 28 Jun 83)

GERSHBEYN, E.A. and PEYGIN, S.V., Moscow

[Abstract] The equations of a three-dimensional laminar mixing layer at a permeable surface, in a nondegenerate curvilinear system of coordinates, are solved numerically upon introduction of two flow functions which satisfy the condition of continuity and upon subsequent change to Dorodnitsyn variables. The problem is solved for given boundary conditions and initial conditions, the boundary conditions stipulating the concentrations, the velocity components, and the temperature at the surface and at infinity. The method of solution is based on invariance of the system of equations with respect to

translation of the normal coordinate  $\zeta$  through a distance which is an arbitrary sufficiently smooth function of the other two, longitudinal  $\xi$  and transverse  $\eta$ . The algorithm of the solution is that of an implicit four-point finite-difference scheme with  $O(\Delta\zeta)^4 + O(\Delta\xi)^2 + O(\Delta\eta)^2$  accuracy, constructed for a system of three linear equations (momentum, thermal flux, diffusion) of first order with respect to variable  $\zeta$  and applied here to a system of four equations including also the equation of continuity in original variables. The problem has been solved for axisymmetric flow of a multicomponent gas (mixture of  $O_2, O, N_2, N, CN, NO, H_2, HCN, C_2$ , and  $C_3$ ) at a spherical surface, with chemical reactions assumed to be frozen, for a homogeneous compressible gas at the surface of a parabolic cylinder, an ellipsoid, and an elliptic paraboloid, and for a frozen flow of a binary gas ( $N_2$  stream with intense injection of  $H_2$ ) passing an elliptic paraboloid at zero angle of attack. The authors thank G.A. Tirskey for helpful discussion of the results. Figures 6, references 10: 9 Russian, 1 Western. [94-2415]

UDC 517.919:533.9

# MATHEMATICAL MODELING OF METAL VAPORIZATION BY ELECTRON BEAM

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 4, Oct 83  
(manuscript received 11 Apr 83) pp 835-838

FILIPPOV, S.S., CHETVERUSHKIN, B.N. and SHIL'NIKOV, Ye.V., Institute of Mathematics imeni M.V. Keldysh, USSR Academy of Sciences, Moscow

[Abstract] A mathematical model is constructed describing the action of a monoenergetic electron beam on a plane metal surface and its interaction with the metal vapor. The model is based on the system of corresponding equations of radiation gas dynamics. It yields relations for the absorbed energy and heat balance, in the "diffusion" approximation, also vapor temperature-field isotherms and their evolution in time as well as the velocity transient of the evaporation wavefront. Numerical calculations have been made for a 50 keV electron beam of intermediate power ( $10^9$  W/cm<sup>2</sup>) impinging on an aluminum surface. A comparison with action of a laser beam reveals that, while absorption of electrons by metal vapor proceeds slowly and is determined by the density of the substance only, absorption of laser radiation by metal vapor is intense and increases with rising temperature so that the metal surface becomes shielded. Article was presented by Academician A.A. Samarskiy on 27 July 1982. Figures 3, references 8: 7 Russian, 1 Western. [101-2415]

## EXISTENCE OF SOLUTION OF SYSTEM OF EQUATIONS DESCRIBING FILTRATION GAS COMBUSTION

Novosibirsk ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI in Russian  
Vol 142, No 6, Nov-Dec 83 (manuscript received 11 Nov 82) pp 67-71

LAYEVSKIY, Yu.M., Novosibirsk

[Abstract] The author considers a two-temperature model of combustion wave propagation in a chemically inert porous medium with filtration of a combustible gas mixture. Approximate solution of the steady-state equations of this model corresponds satisfactorily to the results of experiments done at the Institute of Chemical Kinetics and Combustion, Siberian Department, USSR Academy of Sciences. The physical basis of the process is recuperation of energy as a consequence of conductive transfer through the body and interphase heat exchange, disregarding pressure gradient. This paper demonstrates the existence of a solution of the system of equations describing the process of filtration gas combustion, and an asymptotic solution is given for the wave velocity corresponding to the approximate solution. References 6 Russian.  
[134-6610]

UDC 539.3:534.1

## SOLITONS IN APPRECIABLY NONLINEAR ONE-DIMENSIONAL CHAIN

Novosibirsk ZHURNAL PRIKLADNOY MEKhanIKI I TEKHNIChESKOY FIZIKI in Russian  
Vol 142, No 6, Nov-Dec 83 (manuscript received 10 Sep 82) pp 156-159

VEDENOVA, Ye.G., MANEVICH, L.I., NISICHENKO, V.P. and LYSENKO, S.A., Moscow

[Abstract] A detailed numerical analysis is made of soliton modes in a one-dimensional chain of masses joined by massless string in interacting with strongly nonlinear elastic supports. The results show the existence of a spatially localized steady-state solution, indicating the feasibility of many-soliton modes. In the case of strong coupling and weak spatial localization, the first few terms in the power-law expansion of the nonlinear characteristic predominate. On the other hand, if coupling along the chain is weak, and localization is strongly pronounced, the overall time period is determined satisfactorily by the equation of motion of the principal mass in sawtooth oscillation. Figures 5, references 7: 4 Russian, 3 Western.  
[134-6610]



## ALTERNATIVE METHOD OF DESCRIBING CRYSTALLIZATION KINETICS

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 46, No 1, Jan 84  
(manuscript received 1 Sep 82) pp 124-128

MALKIN, A.Ya., KIPIN, I.A., BOLGOV, S.A., and BEGISHEV, V.P., Institute of Mechanics of Continuous Media, Ural Science Center, USSR Academy of Sciences, Perm, and Plastmassy Scientific Production Association, Moscow

[Abstract] The classical method of describing crystallization kinetics based on the Avrami-Kolmogorov equation is ineffective for solving problems that are complicated by heat transfer, since there is no simple generalization of the equation to a nonisothermal process. The search for an alternative description has shown that an equation of macrokinetic type can be formulated that describes the phase transition kinetics as an autocatalytic process. The authors consider the implicit question of the general correspondence between this expression and the Avrami-Kolmogorov equation, which is important since the classical method satisfactorily describes a large body of experimental data. It is shown that the new expression with certain constraints can be treated as a special case of the Avrami-Kolmogorov equation, and that it gives as good a description of experimental facts as the classical equation, and in the region of limiting degrees of conversion is patently better. Moreover, the equation of autocatalytic type is much more convenient for handling nonisothermal problems. Figures 3, references 4 Russian.

[137-6610]

UDC 536.24.01

## COOLING OF SEMIINFINITE BODY UNDER CONDITIONS OF NONLINEAR HEAT TRANSFER AT SURFACE

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 45, No 4, Oct 83  
(manuscript received 11 May 82) pp 633-635

BABENKO, Yu.I.,

[Abstract] The problem of convective heat transfer at a surface with a nonlinear boundary condition is solved for cooling of a semiinfinite body, the boundary condition being  $\lambda \frac{\partial T}{\partial x} \Big|_{x=0} = \sigma T_s^4$  ( $\lambda$ -thermal conductivity of body material,  $T_s$  - surface temperature,  $\sigma$ - radiation constant). The object is to determine the surface temperature as function of time. When the temperature field is not sought, the method of solution becomes quite simple and yields an asymptotic law of heat transfer toward the end of the transient period.

The solution is sought in the form of a power series  $T_0 - T = \sum_{n=1}^{\infty} \alpha_n t^{\frac{1}{2n}}$  ( $\alpha_n$ -

thermal diffusivity,  $t$ - time), it is found upon fractional-order differentiation of the temperature difference  $T_0 - T_s$  and evaluation of integrals of the  $J = \int_0^t \frac{f(\tau)}{t-\tau} d\tau$  form with  $f(\tau) = T_s^4(\tau)$ . References 3: 2 Russian, 1 Western.

[93-2415]

UDC 536.46:662.421

## CONDITIONS OF FILTRATION BURNING OF POROUS CONDENSED SYSTEMS WITH MULTIPLE PASSAGE OF REACTION WAVE

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 46, No 1, Jan 84  
(manuscript received 28 Sep 82) pp 71-77

RABINOVICH, O.S., KRASIL'SHCHIKOV, S.N. and GUREVICH, I.G., Institute of Heat and Mass Exchange imeni A.V. Lykov, BSSR Academy of Sciences, Minsk

[Abstract] The use of filtration burning in technology necessitates determination of productivity, which depends on the rate of propagation of the reaction wave through the condensed phase. In this paper, the authors

consider possibilities for optimizing technological processes involving filtration burning with repeated passage of the reaction wave (multiwave modes). It is shown that the condition of constant combustion temperature for the entire sequence of waves yields a rather simple expression characterizing efficiency of multiwave filtration combustion modes. To study the principles that govern such modes, an expression is derived for the rate of propagation of a wave of exothermic reaction in the case of non-zero initial depth of conversion of the material being processed. The analysis is based on a system of equations of heat and mass transfer and chemical kinetics describing this wave process, written in a coordinate system that moves with the reaction wave in the Zel'dovich-Frank-Kamenetskiy approximation. It is shown that in the case of waves traveling in the same direction, increasing the number of waves enhances the effect of using a multiwave filtration combustion process, approaching some limit that depends on the conditions of organization of the process. Analysis of the relative increase in efficiency of the multiwave mode of filtration burning as a function of the number of waves shows that a 2-4 wave process is of greatest practical interest for waves traveling in the same direction. Figures 4, references 10 Russian. [137-6610]

UDC: 519.852.6

STABLE METHOD FOR SOLVING LINEAR PROGRAMMING PROBLEM WITH APPROXIMATE DATA

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 5, Oct 83  
(manuscript received 7 Jun 83) pp 1058-1063

TIKHONOV, A.N. Academician, RYUTIN, A.A. and AGAYAN, G.M.

[Abstract] Linear programming problems with the matrix and right part of the limitations assigned approximately are stated and investigated; the existence of a unique solution to the corresponding regularization problem is proposed, and stable methods for solving the problems are proposed. The concept of acceptable solutions of an approximate system of linear algebraic equations with allowance for limitations is employed. The regularization linear programming problem with approximately assigned limitations is stated on the basis of determining the acceptable solution of the approximate system. A numerical example is given. References 5 Russian.  
[118-6900]

UDC 519.852

TWO-PHASE METHODS OF SOLVING CANONICAL PROBLEM OF LINEAR PROGRAMMING

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 27, No 9, Sep 83  
(manuscript received 28 Dec 82) pp 787-790

GABASOV, R., KIRILLOVA, F.M., KOSTYUKOVA, O.I. and SEN'KO, A.A., Belorussian State University imeni V.I. Lenin; Institute of Mathematics, BSSR Academy of Sciences

[Abstract] Two methods are proposed for solving the canonical problem of linear programming  $c'x \rightarrow \max; Ax = b$  for  $d_* < x < d^*$ , where  $A(I, J)$  is an  $m \times n$  matrix with  $I = \{1, 2, \dots, m\}$  and  $J = \{1, 2, \dots, n\}$ . The direct two-phase method yields the  $\epsilon$ -optimal plan in a finite number of iterations for every  $\epsilon > 0$  and any initial plan  $x$ . This method is applicable when  $A_1 \neq 0$  and when  $A_1 = \bar{0}$  ( $x+1 = x^0$  being the optimum plan). The dual two-phase method yields the  $\epsilon$ -optimal plan for every  $\epsilon > 0$  and any initial coplan  $\delta$ , or it reveals the inconsistency of its constraints. The validity of both methods has been verified by a numerical experiment on a BESM-6 high-speed computer, with the problem also solved by the conventional simplex two-phase method. Article was presented by Academician (BSSR Academy of Sciences) D.A. Suprunenko. Table 1, references 4 Russian.  
[88-2415]

## ECONOMICAL MULTIPLICATION OF BOOLEAN EQUATIONS

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian  
Vol 24, No 1, Jan 84 (manuscript received 9 Mar 83) pp 164-166

ZHURAVLEV, Yu.I. and PLATONENKO, N.M., Moscow

[Abstract] Systems of Boolean equations  $f_i(x_{i1}, \dots, x_{in(i)}) = \alpha_i$  ( $\alpha_i \in \{0,1\}$ ,  $i = 1, 2, \dots, m$ ) are considered where the Boolean functions  $f_i$  cannot be put in the form of linear mod-2 functions of their arguments. There is only one universal method of solving such a system of equations, namely reducing it to a system  $\Psi_i(x_{i1}, \dots, x_{ik(i)}) = 1$  ( $i = 1, 2, \dots, m$ ) and then the latter to an equivalent single equation  $\Psi_1 \dots \Psi_m = 1$  with the left-hand side subsequently represented in the disjunctive normal form  $K_1 \gamma \dots \gamma K_l = 1$  ( $K_i, i = 1, 2, \dots, l$  elementary conjunctions), then solving successively the trivial equations

$$K_i = x_{i1}^{\sigma_i} \dots x_{ik(i)}^{\sigma_{ik(i)}} = 1 \quad (i = 1, 2, \dots, l). \quad \text{This method becomes ineffective and}$$

impractical for large  $m$ . Another method is therefore proposed which, though not universal, ensures an economical multiplication process in many cases. The problem is reduced to the problem of assignments with minimization of complexity. A qualitative analysis requires only lower-bound estimates, a quantitative solution requires upper-bound or both estimates. The problem is solved beginning with a numerical matrix symmetric with respect to its diagonal and following with a partition of the system of equations  $\Psi_i(x_{i1}, \dots, x_{ik(i)}) = 1$  into maximally weighted equation pairs in such a way as to minimize the resultant complexity after multiplication of the left-hand sides. References 4 Russian.

[94-2415]

UDC 519

## SEQUENTIAL METHOD OF MINIMIZING NONLINEAR FUNCTION ON SIMPLEX

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 274, No 3, Jan 84  
(manuscript received 10 Jun 83) pp 544-547

MIKHALEVICH, V.S., academician (UkSSR Academy of Sciences), and REDKOVSKIY, N.N., Institute of Cybernetics, UkSSR Academy of Sciences, Kiev

[Abstract] A numerical method is proposed for minimizing a function  $f(u)$  on

a set  $S_u = \{u: \sum_{i=1}^N u^i = 1, u^i \geq 0, i = 1, 2, \dots, N\}$ ,  $u$  being an element of the Euclidean space  $E^N$  with components  $u^1, u^2, \dots, u^N$ . The method combines

sequential analysis of variants and algorithms with accelerated convergence. It subdivides the simplex  $S_u$  on each minimization step into subsimplexes of dimensionality  $m \leq n < N$ . Following an analysis of  $(f'(u_0), p)$  (vector  $p = e_j - u_0$ ), a rule can be constructed for selection of indices  $j$  in set  $I_m$  which define the subsimplex on which minimization is being performed. An appropriate change of variables  $u = u(x)$  will reduce the original minimization to minimization of function  $f[u(x)]$  on a sphere  $S_x = \{x: ||x||^2 = 1\}$ . The procedure is shown for  $e$ , a positive fixed number and  $d_k > 0$  a sequence tending to zero. Two theorems are stated, one pertaining to the necessary condition for existence of a minimum and one pertaining to estimates of the convergence rate. References 4 Russian.  
[110-2415]

END